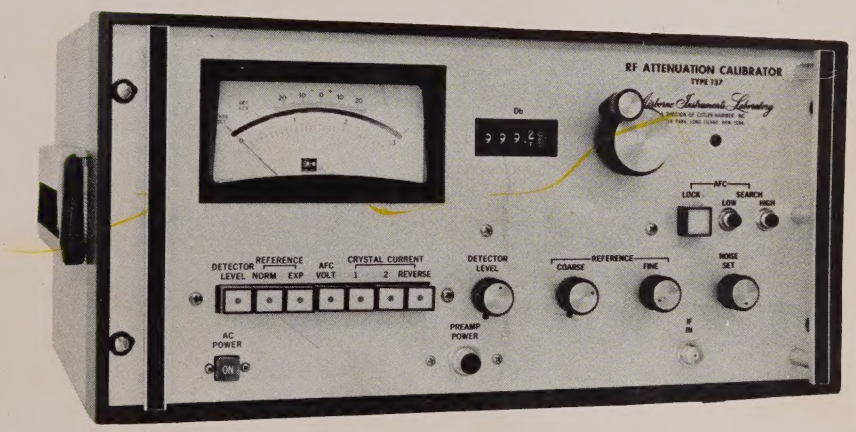
INSTRUCTION
MANUAL
FOR·····

Type 137

RF Attenuation Calibrator



137 Revision B

AIRBORNE INSTRUMENTS LABORATORY A DIVISION OF CUTLER-HAMMER
DEER PARK, LONG ISLAND, NEW YORK 11729

INSTRUCTION MANUAL FOR.....

Type 137

RF Attenuation Calibrator

AIRBORNE INSTRUMENTS LABORATORY
DEER PARK, LONG ISLAND, NEW YORK 11729

A DIVISION OF CUTLER-HAMMER

CONTROL AIL DIVISION

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TABLE OF CONTENTS

		Page
I.	Introduction	1-1
II.	Specifications	2-1
III.	Operating Controls and Indicators	3-1
IV.	Operating Instructions	4-1
	4-1 Introduction	4-1
	4-2 RF Attenuation Measurements	4-2
	4-22 IF Attenuation Measurements	4-10
	4-27 Frequency Deviation Measurements	4-12
	4-34 Amplitude Modulation Measurements	4-15
	4-35 Null Measurements	4-16
	4-36 Noise Figure Measurements	4-20
V.	Theory of Operation	5-1
	5-1 System Description	5-1
	5-2 Subsystem Description	5-3
	5-5 Audio Subsystem	5-6
	5-6 AFC Subsystem	5-7
	5-7 Subassembly Description	5-11
	5-9 Preamplifier Converter	5-16
	5-10 30-MHz Preamplifier	5-21
	5-11 Precision Attenuator	5-25
	5-12 Noise Generator	5-26
	5-13 Postamplifier	5-26
	5-14 AFC Detector	5-35
	5-15 Audio Amplifier/Detector	5-40
	5-16 1-kHz Oscillator	5-45
	5-17 Power Supply	5-49
VI.	List of Replaceable Parts	6-1

			Page
VII.	Maintenance Instructions		7-1
	7-1	General	7-1
	7-2	Trouble Analysis of RF Attenuation Calibrator	7-1
	7-22	Routine Maintenance	7-21
	7-29	Factory Repair	7-23
VIII.	DC Voltage Tables		8-1
	8-1	General	8-1
Appendixes			
	A--Accessory Items Available for Use With Type 137 RF Attenuation Calibrator		A-1
	B--Techniques of Attenuation Measurement		B-1

LIST OF ILLUSTRATIONS

Figure		Page
1-1	AIL Type 137 RF Attenuation Calibrator, P/N 13710	1-1
2-1	AIL Type 137 RF Attenuation Calibrator and Preamplifier P/N 13730, Outline Dimensions	2-3
3-1	Type 137 Front Panel Controls, Indicators, and Connectors	3-1
3-2	Type 137 RF Attenuation Calibrator, Rear View	3-3
3-3	Preamplifier Converter Connectors	3-4
4-1	Typical Test Setup	4-1
4-2	Basic RF Attenuation Measurement Equipment	4-3
4-3	Frequency Response Spectrum	4-8
4-4	Frequency Deviation Measurement Setup	4-12
4-5	Ratio Detector Output	4-14
4-6	Incidental FM as Displayed on Oscilloscope	4-17
4-7	Calculation of Amplitude Modulation	4-17
4-8	Modulation Waveforms, Low Modulation	4-18
4-9	Modulation Waveforms, High Modulation	4-19
4-10	Noise Figure Measurement Setup	4-20
4-11	Noise Figure vs Y-Factor for Various Discharge Noise Generators	4-23
5-1	Simplified System Block Diagram	5-2
5-2	70-MHz Subsystem Block Diagram	5-3
5-3	Frequency Response of 70-MHz Amplifier	5-4
5-4	Audio Detector Subsystem	5-6
5-5	AFC Loop Block Diagram	5-8
5-6	Simplified AFC Loop	5-8
5-7	Ratio Detector Output	5-10
5-8	Type 137 Precision RF Attenuation Calibrator Schematic	5-13
5-9	Filter Schematic	5-15
5-10	Preamplifier-Converter Block Diagram	5-17
5-11	Preamplifier-Converter Schematic	5-19
5-12	30-MHz Preamplifier Block Diagram	5-22

Figure		Page
5-13	IF Preamplifier Schematic	5-23
5-14	Noise Generator Block Diagram	5-27
5-15	Noise Generator Schematic	5-29
5-16	Postamplifier Block Diagram	5-31
5-17	Postamplifier Schematic	5-33
5-18	AFC Detector Block Diagram	5-36
5-19	AFC Detector Schematic	5-37
5-20	Audio Amplifier Detector Block Diagram	5-41
5-21	Audio Amplifier Detector Schematic	5-43
5-22	1-kHz Oscillator Block Diagram	5-46
5-23	1-kHz Oscillator Schematic	5-47
5-24	Power Supply Schematic	5-50
7-1	Bottom View of Type 13710 RF Attenuation Calibrator	7-2
7-2	Top View of Type 13710 RF Attenuation Calibrator	7-3
7-3	Waveforms at P10	7-10
7-4	Waveforms at J8 and J6	7-12
7-5	Waveforms at P9	7-20
B-1	Assumed Conditions for Definition of Insertion Loss	B-2
B-2	Actual Conditions for Measurement of Insertion Loss	B-3
B-3	Use of Tuners in Attenuation Measurement	B-6
B-4	Leakage Path Around an Unknown Attenuator	B-8
B-5	Measurement of Leakage Path	B-9

SECTION I

INTRODUCTION

The AIL Type 137 RF Attenuation Calibrator uses the well-known IF series substitution method for the accurate measurement of attenuation at radio frequencies (Figure 1-1). Using newly developed techniques, it has a single-step measurement capability of from 0.01 to 100 dB over the frequency range from 10 MHz to 40 GHz. The AIL Type 137 features operational simplicity, integral automatic frequency control, solid-state design, internal modular construction, and a plug-in mixer capability; it is ideally suited for the calibration laboratory as well as production line use. The AIL Type 137 can also be used for sensitive null measurements, amplitude modulation measurements, noise figure measurements, and frequency deviation measurements. Some of its many uses are:

- Calibration of RF and IF attenuators and directional couplers
- Calibration of signal-generator output attenuators
- Measurement of gain, selectivity, and linearity characteristics of RF and IF amplifiers

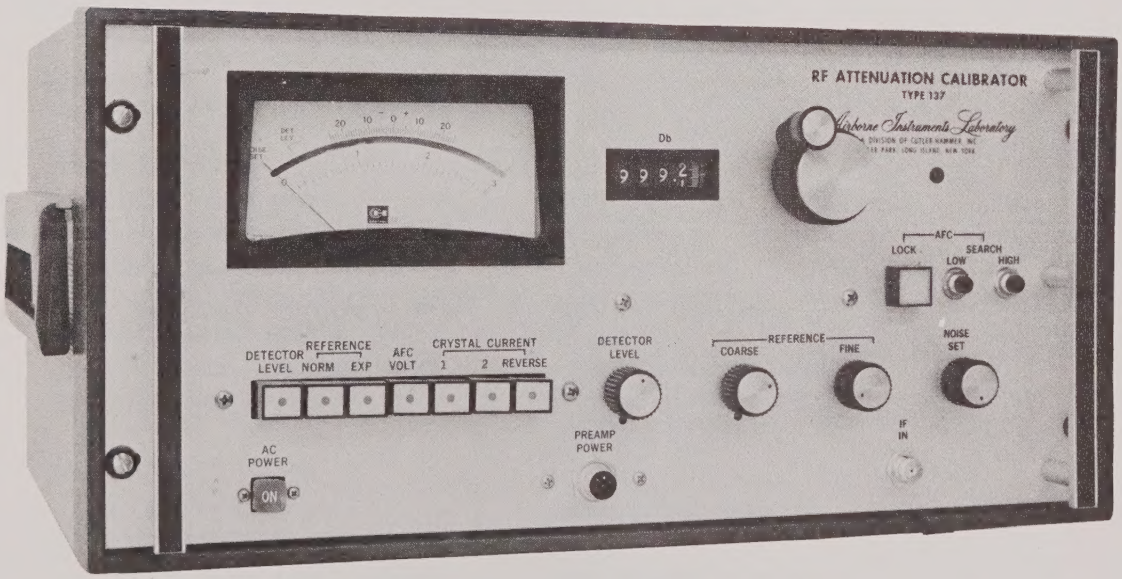

FIGURE 1-1. AIL TYPE 137 RF ATTENUATION CALIBRATOR, P/N 13710

- Measurement of transmission and selectivity characteristics of RF and IF components (isolators, tuners, power dividers, etc.)
- Measurement of noise figure of mixers and amplifiers
- Measurement of contact losses and hysteresis in RF and microwave switches

The Type 137 RF Attenuation Calibrator (Figure 1-1) consists of a main unit (Part Number 13710) and a preamplifier-converter (Part Number 13730).

Accessory items available for use with the Type 137 RF Attenuation Calibrator will enable a variety of measurements. These items (listed in Appendix A) include Precision IF Attenuators, Noise Generators, Noise Generator Power Supplies, Mixers, Preamplifiers, Impedance Adapters, Sweep Oscillators, and Crystal Test Set.

SECTION II

SPECIFICATIONS

1. Frequency range — 10 MHz to 40 GHz (determined by mixer, see Appendix A)

2. RF attenuation measurement range — 100.00 dB max, 0.01 dB min

3. RF attenuation measurement accuracy

Attenuation Step (dB)	Measurement Accuracy (dB)
10	±0.04
20	±0.05
40	±0.07
80	±0.20
90	±0.30
100	±0.40

4. Signal sensitivity

RF (mixer input)	-115 dBm
IF (30-MHz receiver input)	-125 dBm

5. Automatic frequency control

Frequency drift correction	1000 to 1 min (Note 1)
Frequency drift range	±5 MHz
Minimum RF signal level	-115 dBm (into mixer)
Frequency lock-on	Green indicator light
Search range	±15 MHz (typical)

6. Discriminator output

AFC FAST (scope presentation)	200 mV/MHz (typical)
AFC SLOW (100 k output impedance)	1000 V/MHz (typical)

Note 1. At signal levels below approximately -90 dBm the correction is less.

7.	Output reference indication	
	Meter	
	Reference	
	Normal	0.2 dB/division
	Expand	0.008 dB/division (Note 2)
	Crystal	0 to 3 mA
	Recorder output jack	
	Output impedance	5.7 kilohms
	Output voltage	50.0 mV maximum
8.	Precision attenuator	
	Center frequency	30 MHz
	Minimum insertion loss	18 dB (nominal)
	Input impedance (nominal)	50 ohms
	Output impedance (nominal)	50 ohms
	Attenuation range	0.00 to 100.00 dB above minimum insertion loss
	Accuracy	0.005 dB/10 dB + 0.03 dB
	Resolution	0.01 dB/division
9.	Power required	115/230 VAC ±10 percent, 50 to 400 Hz 40 W
10.	Size P/N 13710 (Figure 2-1)	20 × 9-7/8 × 14-1/2; front panel 8-3/4 × 19
	P/N 13730 (Figure 2-1)	7-1/4 × 3-1/4 × 1-1/4
	Weight P/N 13710	30 pounds
	P/N 13730	2 pounds

Note 2. At signal levels below approximately -90 dBm the normal scale is recommended.

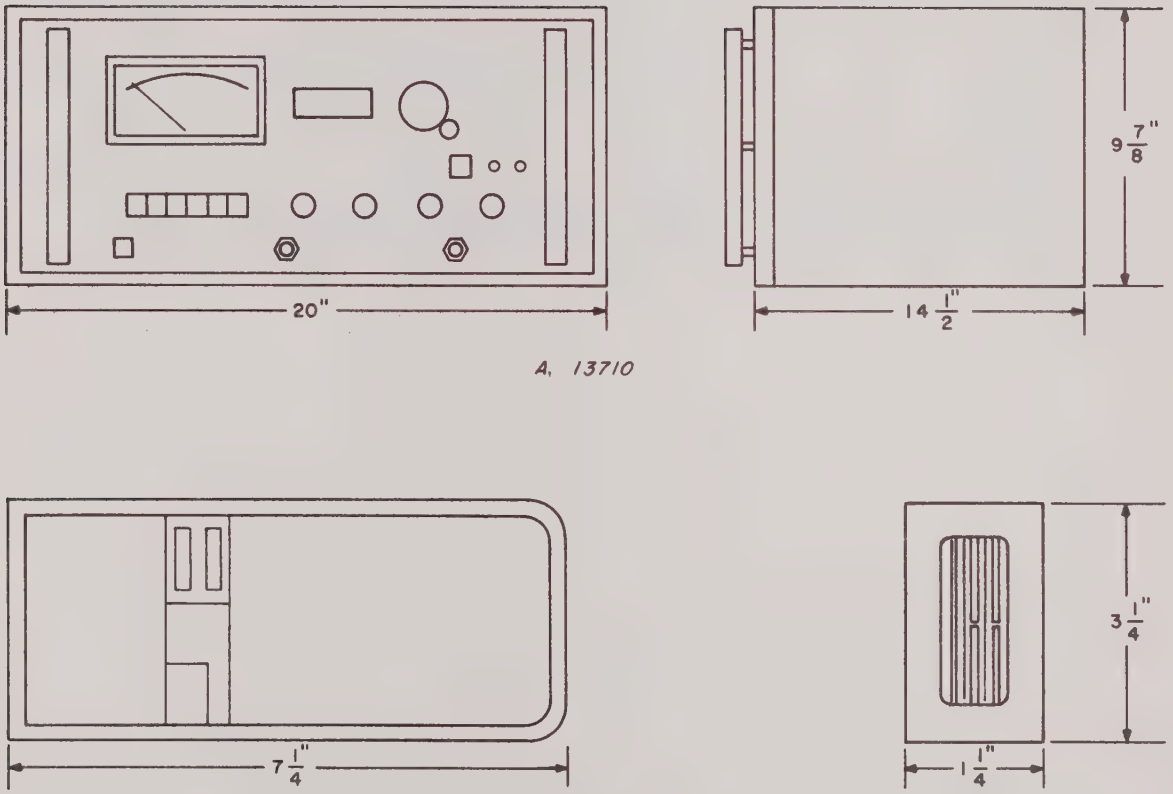

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FIGURE 2-1. AIL TYPE 137 RF ATTENUATION CALIBRATOR AND PREAMPLIFIER P/N 13730 OUTLINE DIMENSIONS

SECTION III

OPERATING CONTROLS AND INDICATORS

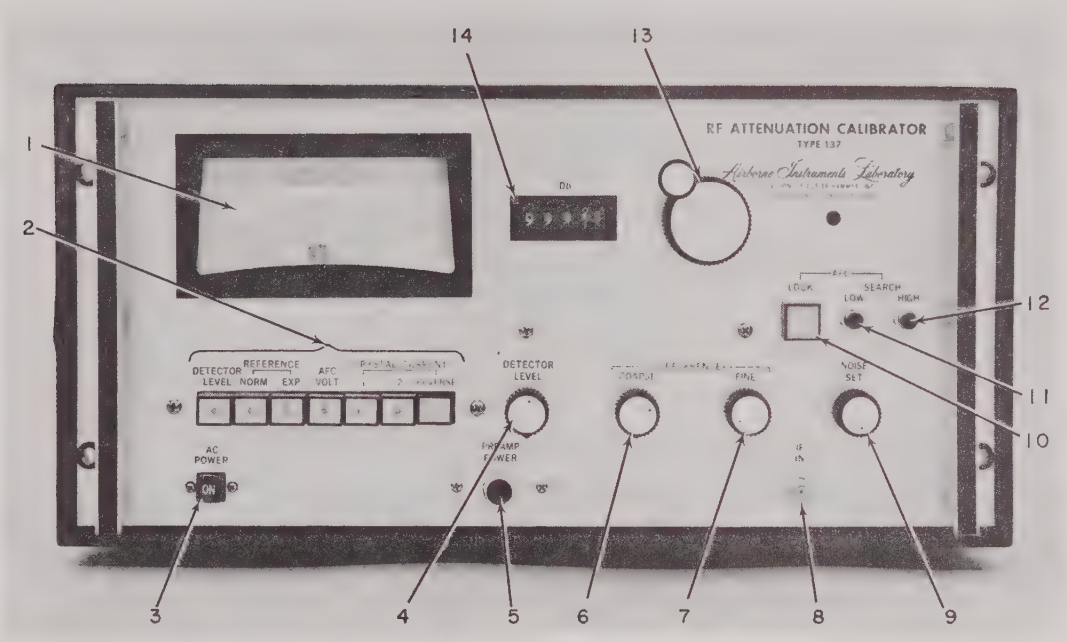


FIGURE 3-1. TYPE 137 FRONT PANEL CONTROLS, INDICATORS, AND CONNECTORS

Reference Number	Control/Indicator	Function
1	Meter	Indicates second detector level, output reference level, or crystal current as selected by switch 2.
2	Meter function switch, seven position	Selects meter function.
	DETECTOR LEVEL	Shows IF postamplifier detector current.
	REFERENCE NORM	Shows output level with normal sensitivity.
	REFERENCE EXP	Shows output level with increased sensitivity.
	CRYSTAL CURRENT 1	Shows diode current in RF crystal 1.
	CRYSTAL CURRENT 2	Shows diode current in RF crystal 2.
	CRYSTAL REVERSE	Reverse meter connections when monitoring crystal current.

Reference Number	Control/Indicator	Function
3	AC POWER indicator-switch	Controls AC input power. Illuminates when power is on.
4	DETECTOR LEVEL control	IF postamplifier gain control used to set detector signal level.
5	PREAMP POWER connector	Used to supply power to the preamplifier-converter, control voltage for the VCO, and provide a connection for monitoring crystal current.
6	REFERENCE COARSE control	Used with REFERENCE NORM or EXP to make coarse setting of reference level.
7	REFERENCE FINE control	Used with REFERENCE NORM or EXP to make fine setting of reference level.
8	IF IN connector	Provides access to the input of the 30-MHz preamplifier.
9	NOISE SET control	Used to adjust the output of the internal noise generator. Used with REFERENCE NORM only. Has friction bearing to stabilize against vibrations.
10	AFC SEARCH-LOCK indicator	Indicates when AFC is locked to a signal. Also when no signal is present, it indicates large noise unbalance. Full scale reading is 30 volts.
11	AFC SEARCH-LOCK LOW	Manually operated. Press and release to activate. Provides a signal which causes the VCO to scan from approximately 85 to 100 MHz.
12	AFC SEARCH-LOCK HIGH	Manually operated. Press and release to activate. Provides a signal which causes the VCO to scan from approximately 115 to 100 MHz.
13	Precision attenuator control	Used to adjust the setting of the precision attenuator.
14	DB indicator	Relative attenuation in dB.

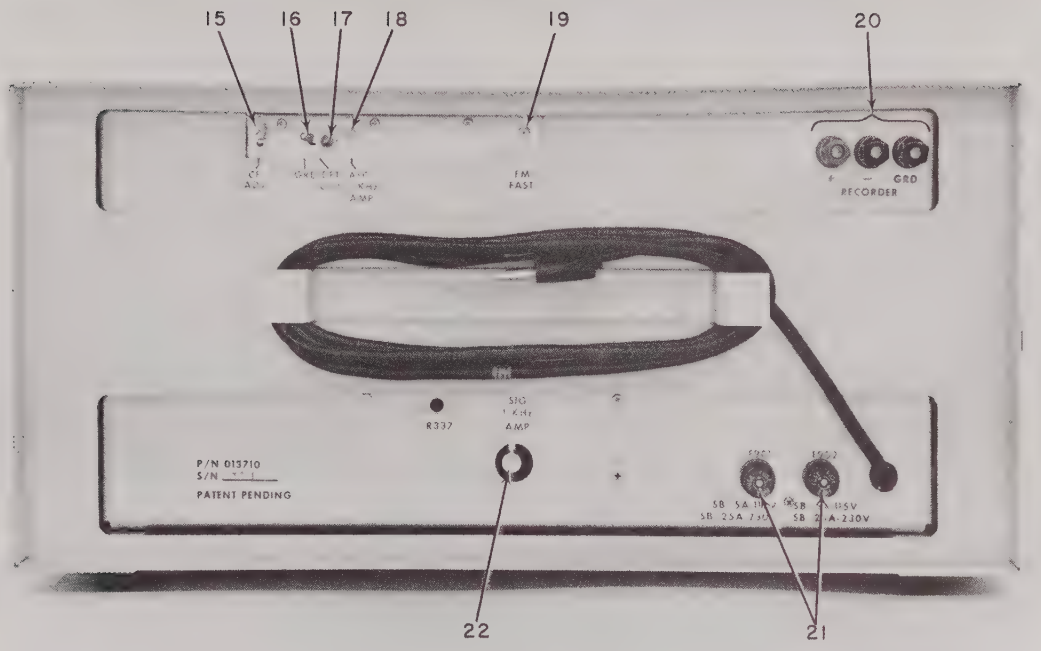


FIGURE 3-2. TYPE 137 RF ATTENUATION CALIBRATOR, REAR VIEW

Reference Number	Control/Indicator	Function
15	CF ADJ	Calibration adjustment for setting the VCO center frequency.
16	GRD	Provides ground connection.
17	DET OUT connector	Used to monitor the output of the AFC coherent detector.
18	AFC 1 KHz AMP connector	Used for maintenance purposes to monitor the audio signal at the input to the coherent detector in the AFC channel.
19	FM FAST	Monitor point for discriminator output used to measure incidental frequency deviation of the signal sources.
20	RECORDER terminals	The (+) and (-) terminals provide direct connection to the front panel meter through a 4.7 k resistor. The + terminal is grounded by a switch.

Reference Number	Control/Indicator	Function
21	F901, F902	Fuseholders for input line fuses.
22	SIG 1 KHz AMP connector	Used for maintenance purposes to monitor the audio signal at the input to the coherent detector in the signal channel.

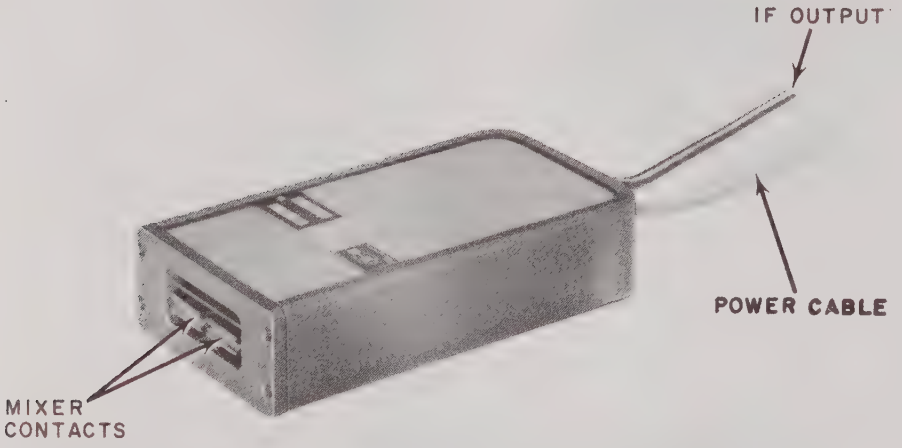


FIGURE 3-3. PREAMPLIFIER CONVERTER CONNECTORS

23	IF output	IF output to front panel.
24	Power cable	Connects power to preamplifier.
25	Mixer contacts	Provides contacts to mixer output.

SECTION IV

OPERATING INSTRUCTIONS

4-1 INTRODUCTION

The Type 137 RF Attenuation Calibrator may be used to perform measurements of RF attenuation, IF attenuation, frequency deviation, amplitude modulation, and noise figure. It may also be used as a highly sensitive null indicator in bridge and switched-type comparison systems.

This instrument is based on the series IF substitution principle. In this system, two attenuators, an unknown and variable IF standard, are placed in series between a generator and a detector (Figure 4-1). Essentially, the measurement method consists of keeping the sum of the attenuation of the unknown and the standard at a constant value. The measurement of RF attenuation using the IF substitution method requires the use of a mixer to convert the frequency of the input signal to the 70-MHz center frequency of the first IF preamplifier located in the converter. AIL offers mixers (Appendix A) which can be conveniently mated to the 70-MHz preamplifier and which cover the frequency range of 10 MHz to 40 GHz.

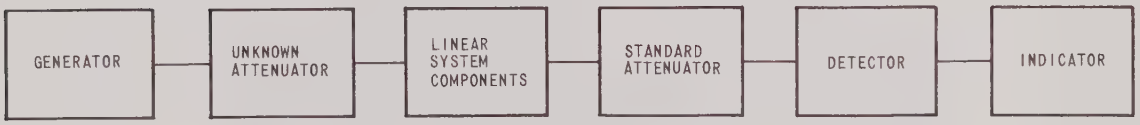


FIGURE 4-1. TYPICAL TEST SETUP

The local oscillators which are needed for obtaining the frequency conversion can be standard commercially available signal sources such as the AIL Type 125 (Appendix A). The AIL Type 137 system has been designed so that it is not necessary to amplitude modulate or electronically control the frequency of the signal sources. Since these functions are not necessary, less sophisticated signal sources and generators may be used.

4-2 RF ATTENUATION MEASUREMENTS

The arrangement of the basic test equipment required for RF attenuation is shown in Figure 4-2. In this system, the mixer converts the change of the RF power level to an equal, linearly related, power level change at the 70-MHz IF. The front panel meter or a recorder may be used to monitor a change in the IF signal level. A precision, highly accurate, waveguide-below-cutoff, IF attenuator (located in the receiver) should be adjusted so that the meter or recorder indicator is at the same position for two conditions: (1) the IF standard is at a 0.00 dB (reference) setting and the unknown RF attenuator is in the system, and (2) the unknown is removed and the system reconnected. There are three major factors that limit the measurement range and accuracy of an IF-substitution system: the nonlinearity of the mixer at high RF signal levels, the effects of the presence of noise at low RF signal levels, and amplitude instability of the IF signal due to frequency variations of the RF signal and local oscillator. In the Type 137, a new noise stabilization technique overcomes the effects of the background noise and a coherent frequency control loop reduces errors caused by frequency variations of the RF signal and local oscillators.

Since the power conversion linearity of the mixer is of prime importance, it is necessary to take certain precautions to assure that deviations from linearity are minimal. The signal level incident on the mixer must be substantially less than the local oscillator level. For linearity deviations to be less than 0.01 and 0.10 dB, the signal power should be 21 and 15 dB, respectively, below the local oscillator power. The AIL Type 135 mixers require approximately 2 mW of local oscillator power (1.0 mA of crystal current) to ensure optimum noise matching and conversion efficiency. Therefore, when performing single-step RF attenuation measurements of less than 80 dB, the signal power should be set for approximately -20 dBm and the local oscillator power should be set for approximately +3 dBm. When attenuators are inserted into the system to improve the VSWR of the mixer, the power levels should be increased accordingly. The operator should perform a run of measurements using a "boot strap" technique to obtain a linearity curve for the mixer he uses.

Good RF attenuation measurement techniques and practices require that certain precautions be observed in order to eliminate or minimize system measurement errors. In the measurement process some of the errors will be random and their effect can be reduced by averaging the results of a number of measurements. An example of a random error is the operator's inability to reset the position of the meter pointer exactly to the reference position after removing the unknown RF attenuator.

Techniques for reducing measurement errors due to mismatch, signal source instability, RF leakage, and alignment variations are discussed in Appendix B (Techniques of Attenuation Measurement).

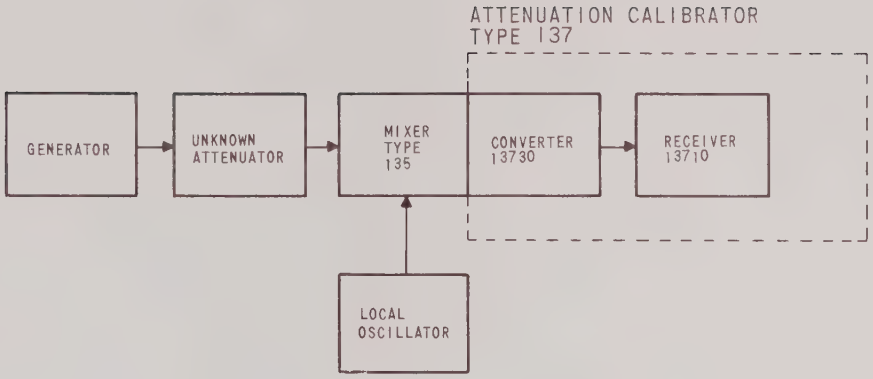


FIGURE 4-2. BASIC RF ATTENUATION MEASUREMENT EQUIPMENT

4-3 INITIAL TURN-ON PROCEDURES

a. Connect converter power cable to PREAMP POWER connector of receiver.

b. Connect IF coaxial cable of converter to IF IN connector on receiver.

c. Depress AC POWER indicator-switch; the indicator and meter face will light. A 1/2-hour warmup time is recommended prior to taking precision measurements.

d. Rotate precision IF attenuator until a reference reading of 0.00 dB is observed.

NOTE

To eliminate any errors caused by backlash in the attenuator, typically 0.02 dB, always rotate the attenuator in the same direction when obtaining the reference and final settings. It is recommended that the attenuator be rotated in a counterclockwise (CCW) direction.

4-4 CRYSTAL CURRENT ADJUST

a. Set RF local oscillator frequency to approximately 70 MHz higher or lower than the desired operating frequency.

b. Adjust local oscillator output power for approximately +3 dBm, CW operation.

c. Depress CRYSTAL CURRENT 1 switch and observe meter reading on the 3 mA scale. If meter reads offscale (to the left), depress REVERSE switch. The crystal current reading should be approximately 1.5 mA. It may be necessary to readjust the local oscillator power level. To ensure proper mixer operation depress the CRYSTAL CURRENT 2 switch. The crystal current reading should be approximately the same as crystal current 1.

4-5 RF SIGNAL GENERATOR ADJUSTMENTS

a. Depress DETECTOR LEVEL switch and rotate DETECTOR LEVEL control to an extreme CCW position. This corresponds to a minimum IF gain adjustment. Set the REFERENCE COARSE control to approximately 3/4 of an extreme CW position.

b. Set the RF signal generator to the desired operating frequency, CW output.

c. Adjust the signal generator output power for approximately -20 dBm at the mixer input. When it is difficult to measure or determine the power level the following technique may be used. Turn off the local oscillator power and adjust the signal generator output power for approximately 1 mA of crystal current. This will correspond to approximately +3 dBm signal power. Insert a total of 23 dB of attenuation between the generator and mixer; there will be approximately -20 dBm signal power incident on the mixer. Turn on the local oscillator power and reset to the proper level as described previously.

4-6 AUTOMATIC FREQUENCY LOCK

When the frequency difference between the local oscillator and the signal generator is within the capture range of the AFC loop, the green AFC indicator will illuminate.

a. Slowly vary the frequency of the local oscillator until the AFC indicator is illuminated. The system will then be in automatic frequency control.. During this procedure, depress DETECTOR LEVEL switch and observe a peak on the meter. Since the response time of the meter is faster than that of the AFC indicator, it is added convenience to use the meter during the tuning procedure.

b. In many instances it is desirable during a measurement to know the frequency stability of the RF signal and local oscillators. This can be accomplished by observing the AFC voltage on the front panel meter. The frequency drift can be measured according to the instructions in paragraph 4-27.

c. When the frequency settability of the RF sources is "rubbery," or when the frequency dials on the sources have backlash, the AFC search-lock mode will be very useful.

Set the signal generator and LO frequencies to the approximate desired values. If the AFC indicator does not illuminate, the loop will not be locked. Depress and release the Search-Lock High button and wait approximately 10 seconds. If the difference frequency between the RF sources is in the range of about 70 to 85 MHz, the green AFC indicator will illuminate. If not, depress and release the Search-Lock Low button and wait approximately 10 seconds. If the difference frequency between the RF sources is in the range of about 70 to 55 MHz, the green AFC indicator will illuminate.

When the loop is locked adjust the LO frequency so that the VCO voltage is approximately 10 volts. The VCO voltage can be observed by depressing the AFC switch.

4-7 NOISE SET ADJUSTMENT

When making single-step RF attenuation measurements of greater than 40 dB, it is desirable to stabilize the system noise for maximum accuracy. Also, as a standard procedure, it is recommended that the noise set be adjusted when a new mixer is initially connected to the preamplifier-converter unit.

a. Connect the unknown RF attenuator into the system as shown in Figure 4-2.

b. Set the IF precision attenuator at 0.00 dB.

c. Turn off the RF signal generator.

d. Depress the DETECTOR LEVEL switch and rotate the DETECTOR LEVEL control until the meter indicator lies in the area marked DET LEV.

e. Depress REFERENCE NORM switch and adjust the NOISE SET control until the meter indicator is on NOISE SET. To obtain a finer null, increase the gain by adjusting REFERENCE COARSE control in a CW direction.

NOTE

The noise level adjustment which has been performed will only be valid for a measurement in which the precision IF attenuator is set to an initial reference setting of 0.00 dB. However, this adjustment is independent of changes in the DETECTOR LEVEL or REFERENCE control position.

4-8 REFERENCE INDICATION

The series IF substitution method is based upon obtaining the same reference indication when the unknown RF attenuator is both in and out of the system.

a. With the unknown RF attenuator in the system, turn on the RF signal generator and obtain frequency lock. It may be necessary to readjust the local oscillator frequency.

b. Depress the DETECTOR LEVEL switch and adjust the DETECTOR LEVEL control until the meter indicator lies in the area marked DET LEV.

c. Depress REFERENCE NORM switch and adjust the REFERENCE COARSE control until the meter indicator lies approximately at midscale. The resolution of the meter indicator at this setting is approximately 0.10 dB for each division. To increase the resolution, depress REFERENCE EXP switch and adjust the REFERENCE FINE control to obtain a meter indication. The resolution in EXP is approximately 0.008 dB for each division. Note the position of the meter indicator.

d. Remove the unknown attenuator and rotate the IF precision attenuator until the same reference indication is returned as in step c.

e. Read the attenuation in dB directly off the digital indicator. The smallest subdivision on the indicator is equivalent to 0.01 dB.

4-9 REFINEMENTS IN OPERATING TECHNIQUES

After mastering the basic measurement procedure, the operator will be able to improve the facility of measurement through attention to the following refinements in operating techniques.

4-10 AIL Type 135 Balanced Mixers

The method for monitoring crystal current in the AIL Type 135 balanced mixers was described in paragraph 4-4. In most cases, the current flowing through either crystal will be within 20 percent of each other. However, due to aging or damage, a crystal may become defective and the current will be badly unbalanced. It is recommended that if the current unbalance is greater than 50 percent, the diodes should be checked and the faulty unit replaced. The diodes may be checked with the AIL Type 391 Crystal Checker (Appendix A) or an equivalent instrument.

4-11 Crystal Current

When placing the system into automatic frequency control, the local oscillator frequency should be varied until the signal is "captured." Characteristic of many sources, the power output level will change as the frequency is varied; therefore, after the loop is in automatic frequency control, the crystal current should be rechecked.

4-12 RF Signal and Local Oscillator Power Level Instabilities

During a measurement, an error will occur if the local oscillator or signal power levels should vary. The error will be a one-to-one relationship for a change in the level of the signal power. However, the error will be approximately a one-to-eight relationship for a change in the level of the local oscillator power. Therefore, in setting up a measurement system, the least stable RF source should be used, if possible, as the local oscillator.

4-13 Output Meter Scales

When single-step RF attenuation measurements of up to approximately 75 dB are performed, the expanded output scale, REFERENCE EXP, should be used. For attenuation measurement steps of greater than 75 dB, the normal scale, REFERENCE NORM, should be used. When making a single-step measurement of 75 dB or greater, the signal level at the converter input will be approximately -90 dBm or lower. At these low levels, the signal-to-noise ratio is poor and fluctuations in meter indication will occur. On the expand scale, where the sensitivity is 0.008 dB for each division, these fluctuations will be difficult to average visually. However, on the normal scale (0.1 dB/division) the fluctuations will be smaller and the average position of the indicator setting may actually be

more accurately determined. The measurement range at which the operator would use the REFERENCE NORM range rather than EXP is a matter of personal preference and varies with the degree of accuracy required.

4-14 Automatic Time Constant Control

When a single-step attenuation measurements of greater than 75 dB are performed, there will be meter needle fluctuations due to the presence of noise voltages. The method utilized in the Type 137 to reduce these fluctuations is to increase the meter time constant and therefore decrease the effective bandwidth. To relieve the operator from calculations or experimentation to determine the required time constant, an automatic time constant control is featured in the unit. As the REFERENCE COARSE control is rotated clockwise (increased gain) the time constant increases automatically. The meter response will be much slower at low signal levels than at higher signal levels; therefore, when making a measurement, it is advisable to adjust the IF attenuator to its approximate final setting, then wait a few seconds, and then slowly rotate the attenuator control counterclockwise until the reference indication is obtained on the meter.

4-15 Noise Set

It is necessary to adjust the NOISE SET control to obtain accurate single-step RF attenuation measurements of greater than approximately 40 dB. When the REFERENCE COARSE control is rotated in a CW direction, the NOISE SET control increases in sensitivity. At the high sensitivity settings of the control the need for setting the meter needle to the NOISE SET marker on the meter face is important.

When there is no RF input signal (refer to Noise Set procedure), the AFC light also functions as a coarse indicator of a poor setting of the NOISE SET. When the NOISE SET control is misadjusted, the AGC indicator will be illuminated.

4-16 Recorder Reference Indication

In some cases it will be desirable to have a record of the reference indication at the initial and final settings of the IF attenuator. RECORDER terminals are provided at the rear of the unit for this purpose. This has the advantage of using a mechanical memory element rather than the operator's memory for returning to the reference indication. An additional advantage of a recorder output is that the operator can more accurately integrate any fluctuations of the reference indication.

Since the RECORDER output terminals are directly connected to the meter (though a 4.7 k resistor), it is very convenient to monitor crystal current to determine if

any change occurs in the power level of the local oscillator. CRYSTAL CURRENT 1 or 2 switches should be depressed for this measurement.

4-17 Spurious Frequency Responses

In the Type 137 RF Attenuation Calibrator, the RF signal is converted to 30 MHz by double frequency conversion. The first conversion is in the RF mixer and the second is in a wideband mixer having a nominal 100 MHz voltage-controlled local oscillator (VCO) input.

For a fixed RF local oscillator frequency, f_{LO}, the spectrum of the two acceptable RF responses and the principal spurious responses are shown in Figure 4-3. A narrowband, 60 to 80 MHz, bandpass filter positioned between the RF and wideband mixers reduces the spurious responses to a level at least 50 dB below the main response. Furthermore, the AFC loop would not "lock on" to a 130 MHz response because the loop would be 180 degrees out of phase and it would attempt to "push away" rather than capture the signal.

To ensure the loop does not lock on to a minor spurious response, especially when the receiver gain is set to a maximum and the RF signal level is very high, the DETECTOR LEVEL switch position should be used when tuning the external local oscillator. The largest meter deflection will only occur when the RF and local oscillator frequencies are properly set for the desired response.

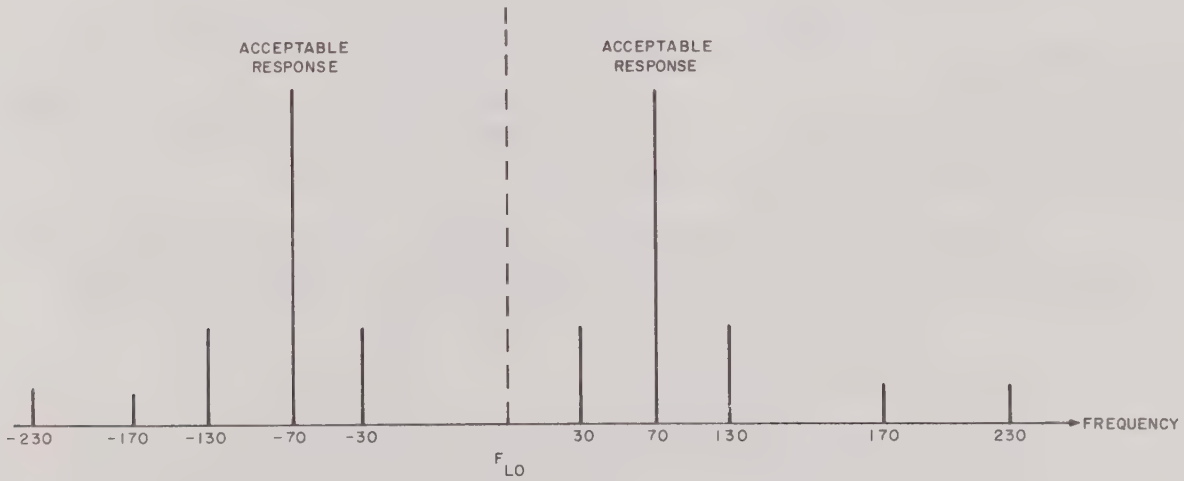


FIGURE 4-3. FREQUENCY RESPONSE SPECTRUM

4-18 AFC Indication

When the heterodyned signal is within the capture range of the VCO, the AFC loop will "lock on." However, this is conditional upon the IF signal level being of sufficient magnitude. When the meter needle lies in the recommended area, DET LEV, there is sufficient signal level to lock the AFC loop. In fact, approximately 10 to 20 dB below this level the loop will still lock but with degraded capture and hold-in range performance.

An indication of AFC lock is provided by an illumination of the AFC light. The audio signal which is fed to the third detector is also used to control the on-off state of the light. When the meter deflection in the REFERENCE NORM position is greater than the minimum scale marking of -25, the audio signal is of sufficient magnitude to turn on the light. When the REFERENCE controls are adjusted so that the indicator lies to the left of the -25 scale mark, the AFC light may go out even if the AFC loop is locked.

Another means for determining that the loop is locked is to connect a high impedance DC voltmeter to the AFC SLOW jack at the rear of the receiver. This voltage controls the VCO frequency and will vary as the nominal 70-MHz IF frequency is varied. Therefore, slowly change the frequency of the RF local oscillator and observe the tracking of the VCO by noting a change in the control voltage (approximately 1/2 volt for each MHz change).

4-19 VCO Correction Voltage

The capture range for the AFC loop at high signal levels is approximately 3 MHz. The VCO "resting" or "no lock" voltage (available at the test terminal, FM SLOW VCO) is nominally 10 volts, which corresponds to a 100-MHz VCO frequency. This means that in order to lock the loop, the frequency difference between the RF signal source and local oscillator must be 70 $\pm$1.5 MHz. However, depending upon the IF gain and noise balance settings this nominal VCO voltage can vary by a few volts. Therefore, when the loop is locked, it is desirable to have the VCO voltage read the same as when no input signal is present. When this condition is satisfied the AFC circuit is operating near the center of its range, the 70-MHz signal is located near the center of the passband of the 70-MHz amplifier, and as a result, maximum stability of the AFC system is obtained.

4-20 AFC Lock at Low Signal Levels

The capture range of the AFC loop will remain constant at high signal levels. However, at low signal levels where poor S/N ratios exist, the AFC loop will have a smaller capture and hold-in range. At low signal levels, it is possible that the incidental FM of the RF signal source and the local oscillator will cause difficulty in obtaining a lock-in action. For these cases, the loop may be more easily locked by first increasing the RF signal level and then decreasing it to the proper level. The usefulness of this technique lies in the fact that the hold-in range of the loop is much greater than its capture range.

4-21 Attenuation Measurements in the Frequency Range of 10 to 1000 MHz

The AFC capability in the Type 137 system minimizes the effect of frequency drift associated with the RF signal and local oscillators. At low frequencies, that is, below 1000 MHz, the stability of most sources will be satisfactory for performing very accurate

attenuation measurements without the need for automatic frequency control. Therefore, it is recommended that our broadband 10 to 1000 MHz mixer, Part Number 13508, be connected directly to the IF input connector on the front panel. A TNC connector is provided with the mixer.

The measurement procedure is modified slightly in that the difference frequency between the signal and local oscillators should be 30 MHz instead of 70 MHz. When a 30-MHz signal is obtained the AFC indicator will be illuminated. This mixer does not have provision for monitoring crystal current; therefore, the LO power should be measured (approximately 5 mW is required). The recommended maximum RF input signal for this case is -10 dBm.

4-22 IF ATTENUATION MEASUREMENTS

The basic IF measurement setup is shown in Figure 4-1. In this system the linear system components should include a fixed attenuator to provide isolation and impedance matching between the unknown and standard attenuators.

A major factor which limits the measurement range and accuracy of the IF-substitution system is the effects of the presence of noise at low signal levels. The presence of noise degrades the resolution and causes an uncertainty in the position of the reference indicator. In the Type 137 system, a coherent amplitude detector improves the resolution and minimizes the uncertainty of the reference indicator position.

Good IF attenuation measurement techniques and practices should be observed in order to eliminate or minimize system measurement errors. The techniques and practices are similar to those required in RF attenuation measurements. Therefore, it is recommended that the operator refer to the appendix entitled "Techniques of Attenuation Measurement."

The basic measurement setup is shown in Figure 4-1. The measurement procedure for a 30-MHz attenuation measurement is as follows.

4-23 INITIAL TURN-ON PROCEDURES

For this measurement the preamplifier-converter Part Number 13730 is not required.

a. Depress AC POWER indicator-switch, the indicator and front panel meter will light. A half-hour warmup time is recommended prior to taking precision measurements.

b. Rotate precision IF attenuator until a reference rating of 0.00 dB is observed.

NOTE

To eliminate any errors caused by backlash in the attenuator, typically 0.02 dB, always rotate the attenuator in the same direction when obtaining the reference and final settings. It is recommended that the attenuator be rotated in a counterclockwise (CCW) direction.

4-24 IF SIGNAL GENERATOR ADJUSTMENTS

a. Set IF signal generator to 30 MHz, CW operation. Adjust generator output so that when the unknown attenuator is not in the system the signal level at the Type 137 IF input will be -10 dBm. When the generator output is set properly the AFC indicator light will illuminate.

b. Depress DETECTOR LEVEL switch and rotate DETECTOR LEVEL control to an extreme CCW position. This corresponds to a minimum IF gain adjustment. Set REFERENCE COARSE adjust to approximately 3/4 of an extreme CW position.

c. To ensure maximum receiver sensitivity, slowly vary generator frequency until a peak is noted on the meter. To obtain maximum resolution, decrease IF signal level so that meter indicator lies in the area marked DET LEV. Depress the REFERENCE NORM or EXP switch to achieve even greater resolution.

4-25 NOISE SET ADJUSTMENT

When making single-step attenuation measurements of greater than 50 dB, it is desirable to stabilize the system noise for maximum accuracy.

a. Connect unknown IF attenuator into the system as shown in Figure 4-1.

b. Set IF precision attenuator at 0.00.

c. Turn off IF signal generator.

d. Depress DETECTOR LEVEL switch and rotate DETECTOR LEVEL control until meter indicator lies in the area marked DET LEV.

e. Depress REFERENCE NORM switch and adjust NOISE SET control until meter indicator is on NOISE SET. To obtain a finer null, increase gain by adjusting REFERENCE COARSE control in a CW direction.

NOTE

The noise level adjustment which has been performed will only be valid for a measurement in which the precision IF attenuator is set to an initial reference setting of 0.00 dB. However, this adjustment is independent of changes in the DETECTOR LEVEL or REFERENCE controls.

4-26 REFERENCE INDICATION

The series IF substitution method is based upon obtaining the same reference indication when the IF attenuator is both in and out of the system.

a. With unknown IF attenuator in the system, turn on IF signal generator, depress DETECTOR LEVEL switch, and adjust DETECTOR LEVEL control until the meter indicator lies in the area marked DET LEV.

b. Depress REFERENCE NORM switch and adjust REFERENCE COARSE control until meter indicator lies approximately at midscale. To increase the resolution, depress REFERENCE EXP switch and obtain a meter indication by adjusting REFERENCE FINE control.

c. Note the position of the meter indicator. When a record of the reference indication at the initial and final setting of the IF attenuator is desired then a recorder should be connected to the RECORDER terminals on the back of the receiver.

d. Remove unknown attenuator and rotate the IF precision attenuator until the same reference indication is returned as in step c.

e. Read attenuation in dB directly off digital indicator. The smallest subdivision on the indicator is equivalent to 0.01 dB.

4-27 FREQUENCY DEVIATION MEASUREMENTS

The Type 137 RF Attenuation Calibrator may be used to provide information on the frequency stability of the RF signal source relative to the RF local oscillator.

The basic frequency deviation measurement setup is shown in Figure 4-4. In this system, a frequency discriminator converts the change in the frequency of the second IF signal to a proportional change in voltage. The nominal second intermediate frequency, f_{IF}, is 30 MHz. This frequency is generated in the double frequency conversion process.

$$f_{IF} = f_{VCO} - |f_{RF} - f_{LO}| \quad (1)$$

where

f_{RF} = frequency of RF signal,

f_{LO} = frequency of RF local oscillator,

f_{VCO} = frequency of VCO, nominally 100 MHz.

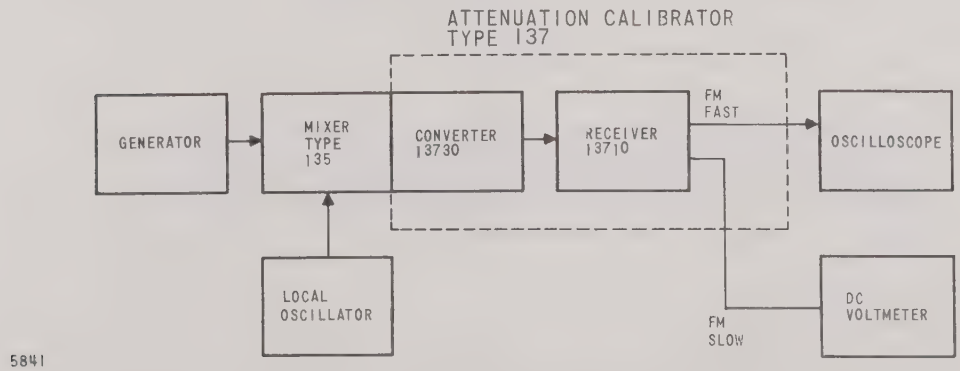


FIGURE 4-4. FREQUENCY DEVIATION MEASUREMENT SETUP

When the solid-state voltage-controlled oscillator is at a much lower frequency than the radio frequency then, in most cases, it is reasonable to assume that it is more stable; therefore,

$$\Delta f_{IF} \doteq \Delta (f_{RF} - f_{LO}) \qquad (2)$$

Thus, the frequency deviation measurement will be a measurement of the stability of one RF source relative to the other.

The accuracy of the measurement is dependent upon knowledge of the voltage-frequency characteristic of the discriminator. To ensure that this characteristic remains relatively constant, it is necessary to provide a signal of sufficient strength for proper limiting action.

When precise knowledge of the voltage-frequency characteristic of the discriminator is required, the following calibration technique may be utilized.

4-28 CALIBRATION OF DISCRIMINATOR CHARACTERISTIC

a. Connect output of a signal generator to IF connector on receiver front panel. The frequency dial on the generator should be calibrated, or a frequency counter should be connected to the generator output.

b. Set generator to 30 MHz and CW mode.

c. Adjust receiver gain to a minimum by turning the DETECTOR LEVEL control fully counterclockwise.

d. Adjust generator output so that receiver indicator lies in marked area DET LEV when DETECTOR LEVEL switch is depressed.

e. Monitor FM SLOW and FM FAST outputs in back of receiver as shown in Figure 4-4.

f. Vary generator frequency and record voltage at the FM SLOW and FM FAST outputs. A voltage-frequency characteristic can then be plotted from the data taken. Figure 4-5 is a plot of data taken from FM FAST output monitor.

g. Slow frequency deviation measurements are generally performed when the AFC loop is locked. Therefore, the FM SLOW frequency-voltage characteristic must be obtained under this condition. The FM FAST characteristic can be measured without the loop being locked. To obtain the FM SLOW frequency-voltage characteristic, vary the VCO control voltage by adjusting control marked CF ADJ and monitor the frequency change of the VCO. A characteristic of MHz/volt will be obtained. It will very nearly be 1.67 MHz/volt.

The procedure for measuring frequency deviation is as follows.

4-29 Initial Turn-On Procedures

a. Connect power cable of preamplifier-converter to the preamp power connector of the receiver. Connect the IF coaxial cable of the converter to the IF IN connector on the receiver.

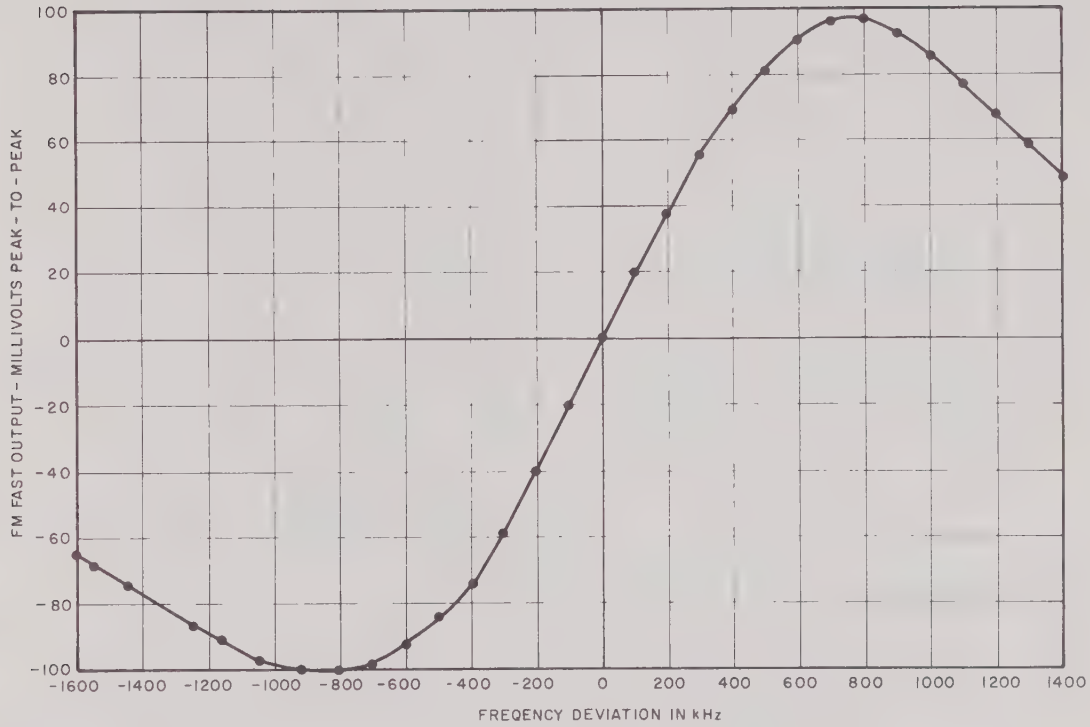


FIGURE 4-5. RATIO DETECTOR OUTPUT

b. Depress the AC POWER indicator-switch, the indicator and front panel meter will light. A one-half hour warmup time is recommended prior to taking precision measurements.

c. Rotate the precision IF attenuator until a reading of 0.00 dB is observed.

4-30 Crystal Current Adjust

a. Set RF local oscillator frequency to approximately 70 MHz higher or lower than the desired operating frequency.

b. Adjust local oscillator power level for a crystal current reading of approximately 1.5 mA.

4-31 RF Signal Generator Adjustments

a. Rotate DETECTOR LEVEL control to an extreme counterclockwise position and depress DETECTOR LEVEL switch. Rotate REFERENCE COARSE control to a 3/4 clockwise position.

b. Set RF signal generator to desired operating frequency, -20 dBm output power, and CW mode.

4-32 AFC Lock

a. Note DC voltage from FM SLOW monitor jack.

b. Slowly vary frequency of local oscillator until AFC indicator is illuminated. When the loop is locked, slowly vary the local oscillator until the voltage in step a is returned. This ensures that the signal frequency is centered within the discriminator bandpass. Thus, for incidental FM measurements the entire discriminator bandwidth can be utilized.

c. Check for proper crystal current. Adjust the local oscillator power output if necessary.

d. Adjust signal generator output so that meter indicator lies in the area marked DET LEV.

4-33 Monitor Discriminator Output

a. To measure incidental FM, observe the peak-to-peak voltage excursion at the FM FAST monitor point.

b. The frequency deviation is calculated by using equation 3.

$$\Delta f = K V_{p-p} \tag{3}$$

where

Δf = frequency deviation

K = slope of discriminator characteristic, 200 mV/MHz

V_{p-p} = peak-to-peak voltage

If a more accurate calculation is desired, then the value of K should be determined from a plot similar to that shown in Figure 4-5. A photograph of the voltage which may typically appear at the FM FAST monitor point is shown in Figure 4-6.

c. To measure slow frequency drift, observe the change in voltage at the FM SLOW monitor point. The value of K for this case is typically 1.67 MHz/volt.

4-34 AMPLITUDE MODULATION MEASUREMENTS

The Type 137 RF Attenuation Calibrator may be used to measure the amplitude modulation on the output of a signal generator. The basic amplitude modulation measurement setup is shown in Figure 4-2. For this measurement it is necessary to connect an oscilloscope to the AM monitor point on the preamplifier-converter. The monitor point is direct coupled to a square-law detector.

The basic method for measuring amplitude modulation is to first measure the detected output (AM monitor point) when no modulation is applied. A DC voltage will be observed. Secondly, measure the detected output when modulation is applied. An audio voltage will be observed. If the carrier level does not change when modulation is applied,

the percent modulation can be calculated from the observed values of voltage. Referring to Figure 4-7, when observations are made using a square-law detector, the percent modulation is:

$$\text{percent modulation} = \frac{V_{p\text{-}p}}{4\,V_{DC}}\ 100 \qquad (4)$$

Figures 4-8 and 4-9 are photographs of oscilloscope displays of the signal and AM monitor output.

The procedure for measuring amplitude modulation is as follows.

a. Follow the procedure given in paragraphs 4-29 through 4-32.

b. Measure the DC voltage at the AM monitor point when no modulation is applied.

c. Measure the AC voltage when modulation is applied.

d. Use equation 4 to calculate percent modulation.

4-35 NULL MEASUREMENTS

There are many applications where it is necessary to know the point of adjustment at which a null occurs. In applications involving bridge measurements, dual channel phase measurements, etc., a reference component is generally adjusted to obtain a null condition. In the case of phase measurements, a phase shifter would be adjusted; when a microwave amplifier is being tuned the matching network would be adjusted. In all these cases, the signal would initially be at same high level. The level would then be decreased to a minimum.

The basic method in performing null measurements is to obtain a reference indication in the same manner as in RF attenuation measurements. However, the signal level in this case will initially be very high. As the null is approached the DETECTOR LEVEL control should be used to keep the detector output near the recommended level (DET LEV). If the approach to the null is relatively slow, the AFC loop will stay in lock. Therefore, the only operating adjustments would be to increase the detector level and reference coarse gain. The initial operating procedures prior to adjusting for a null are similar to paragraphs 4-3 and 4-7. When checking deep nulls approaching the lower limit imposed by system noise, it is necessary to set the precision attenuator at 0.00 dB and follow the normal procedure for adjusting the NOISE SET control. It is important to remember that in making null readings the attenuator must not be varied once the NOISE SET control has been adjusted.

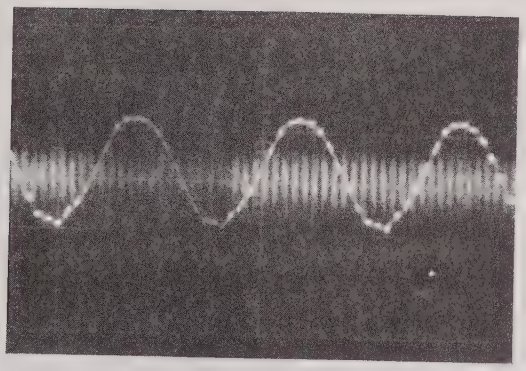
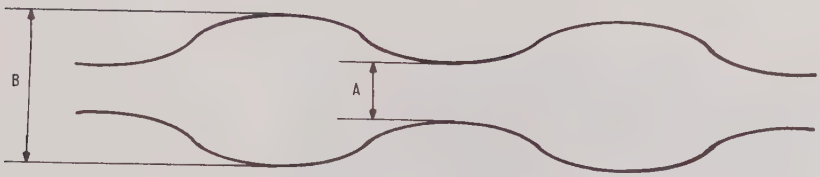
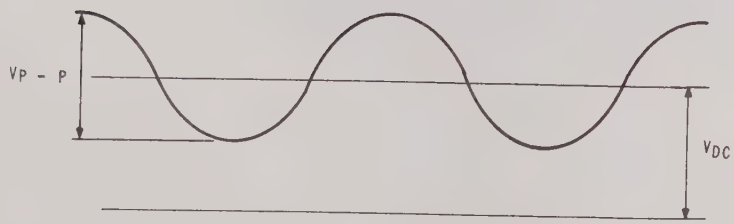


FIGURE 4-6. INCIDENTIAL FM AS DISPLAYED ON OSCILLOSCOPE



$$\text{PERCENT MODULATION} = \frac{B - A}{B + A} 100$$

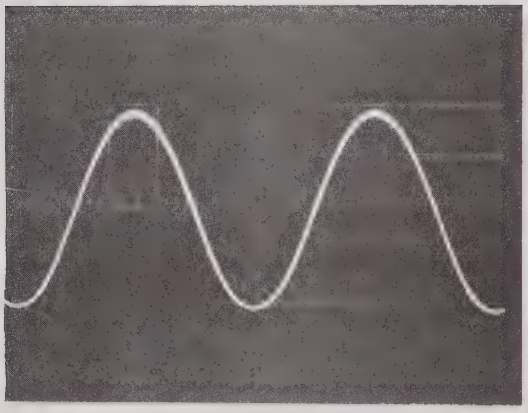
A. ACTUAL SIGNAL



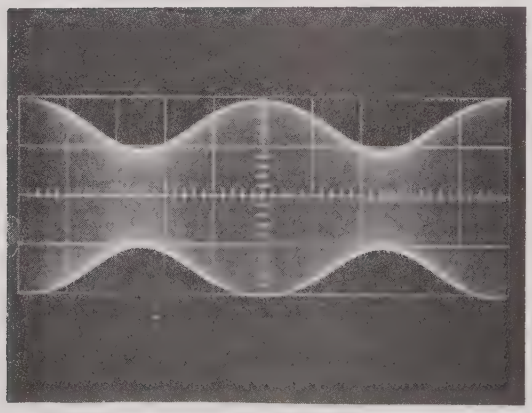
$$\text{PERCENT MODULATION} = \frac{V_{P-P}}{4\ V_{DC}} 100$$

B. SIGNAL AT AM MONITOR

FIGURE 4-7. CALCULATION OF AMPLITUDE MODULATION

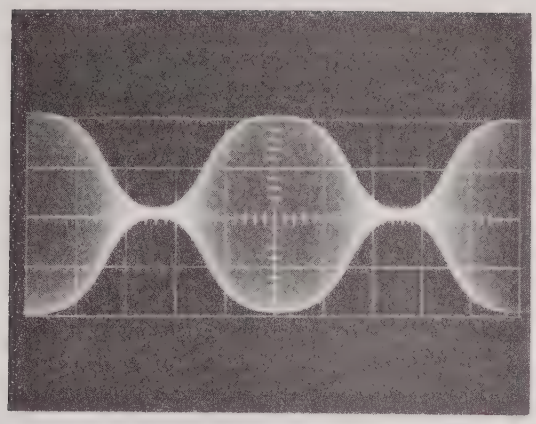


A. IF OUTPUT FROM GENERATOR
PERCENT MODULATION. METER INDICATION - 25

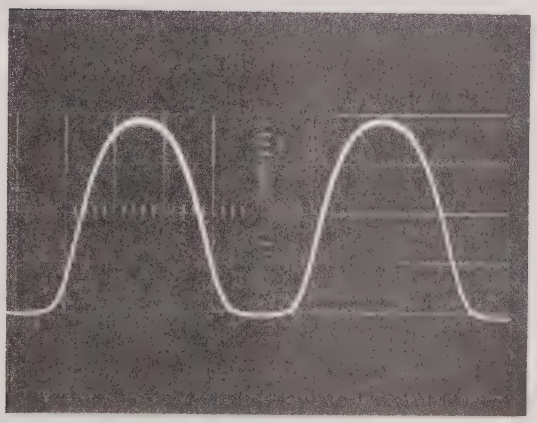


B. DETECTED OUTPUT FROM 137
DC LEVEL - 19 DIVISIONS
AC LEVEL - 20 DIVISIONS
PERCENT MODULATION. CALCULATED - 26

FIGURE 4-8. MODULATION WAVEFORMS, LOW MODULATION



A. IF OUTPUT FROM GENERATOR
PERCENT MODULATION, METER INDICATION - 70



B. DETECTED OUTPUT FROM I37
DC LEVEL - 8 DIVISIONS
AC LEVEL - 20 DIVISIONS
PERCENT MODULATION, CALCULATED - 63

FIGURE 4-9. MODULATION WAVEFORMS, HIGH MODULATION

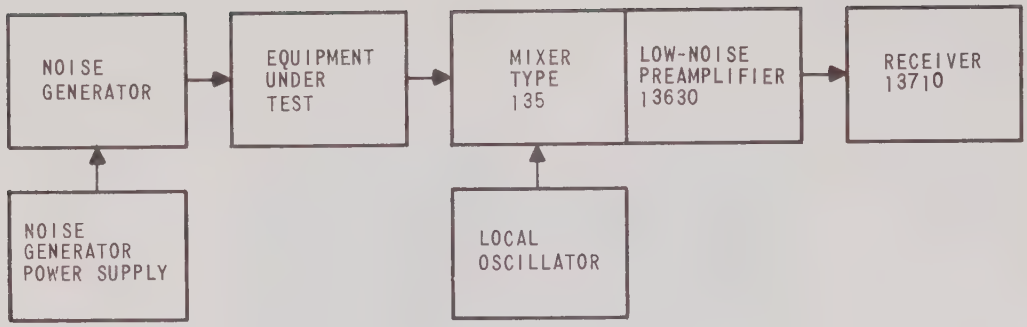


FIGURE 4-10. NOISE FIGURE MEASUREMENT SETUP

4-36 NOISE FIGURE MEASUREMENTS

The arrangement of the basic test equipment used in making noise figure measurements is shown in Figure 4-10. The noise generator can be any one of a number of devices of known relative excess noise ratio. The most common are: (1) gas-discharge lamp, where the relative excess noise ratio is primarily a function of the type of gas, the diameter of the discharge column, and the gas pressure; and (2) the thermionic diode, which has a relative excess noise ratio that is a function of the DC diode current and the terminating source resistance.

A Y-factor method is utilized as the basis for the noise figure measurement. When the noise generator is turned off, the input of the device under test sees a passive termination at T_0. The meter indicator position represents a level of noise, N_{01}. When the noise generator is turned on, the meter indicator will increase to a higher position because of the increase of noise at the input. This new position represents a level of noise, N_{02}. If the precision attenuator in the receiver is rotated until the meter indicator position is returned to the same point as when the noise source was off, then this increase is the Y-factor (N_{02}/N_{01}) expressed in dB. This value can then be converted to a power ratio for substitution in equation 5 and the noise figure can be computed.

$$F = \frac{\left(\frac{T_2}{T_0} - 1\right)}{\left(\frac{N_{02}}{N_{01}} - 1\right)} = \frac{T_{EX}}{Y - 1} \qquad (5)$$

where

T_2 = temperature of noise generator

T_0 = temperature of termination

The basic measurement setup for noise figure measurements is shown in Figure 4-10. The measurement procedure is as follows:

4-37 INITIAL TURN-ON PROCEDURES

a. Connect output of Type 136 low-noise preamplifier to the IF IN connector on receiver front panel; connect power cable of the preamplifier to the PREAMP POWER connector.

b. Depress the AC power indicator-switch; the indicator and front panel meter will light.

c. Rotate the precision IF attenuator until a reference reading of 0.00 dB is observed.

4-38 CRYSTAL CURRENT ADJUST

a. Set RF local oscillator frequency to 30 MHz higher or lower than desired operating frequency.

b. Adjust local oscillator output power for approximately +3 dBm, CW operation.

c. Depress CRYSTAL CURRENT 1 switch and observe the meter reading on the 3 mA scale. If meter pegs downscale, depress REVERSE switch. The crystal current reading should be 1.5 mA. It may be necessary to readjust local oscillator power level. To ensure proper mixer operation, depress CRYSTAL CURRENT 2 switch. It should read approximately the same as crystal 1 current.

4-39 RECEIVER GAIN CONTROL ADJUSTMENTS

a. With noise generator turned off, depress the DETECTOR LEVEL switch and adjust DETECTOR LEVEL control so that meter indicator lies in the area marked DET LEV.

b. Depress the REFERENCE COARSE switch and adjust the REFERENCE COARSE control so that the meter indicator is midscale position.

c. To achieve finer resolution, depress the REFERENCE FINE switch and adjust REFERENCE FINE control to obtain a reference reading, preferably at midscale.

NOTE

The NOISE SET control does not have to be adjusted.

4-40 Y-FACTOR READING

a. Ignite noise lamp by operating noise-generator power supply. Set current adjust control for the proper operating current (refer to the noise-generator handbook).

b. Readjust precision attenuator until meter returns to the reference meter indicator in paragraph 4-39, step c.

c. Read digital dial setting of precision attenuator. This value, in dB, is the Y-factor.

d. Refer to Figure 4-11. Using the T_{ex} curve closest to that given in the noise-generator handbook, read the device noise figure corresponding to the measured Y-factor.

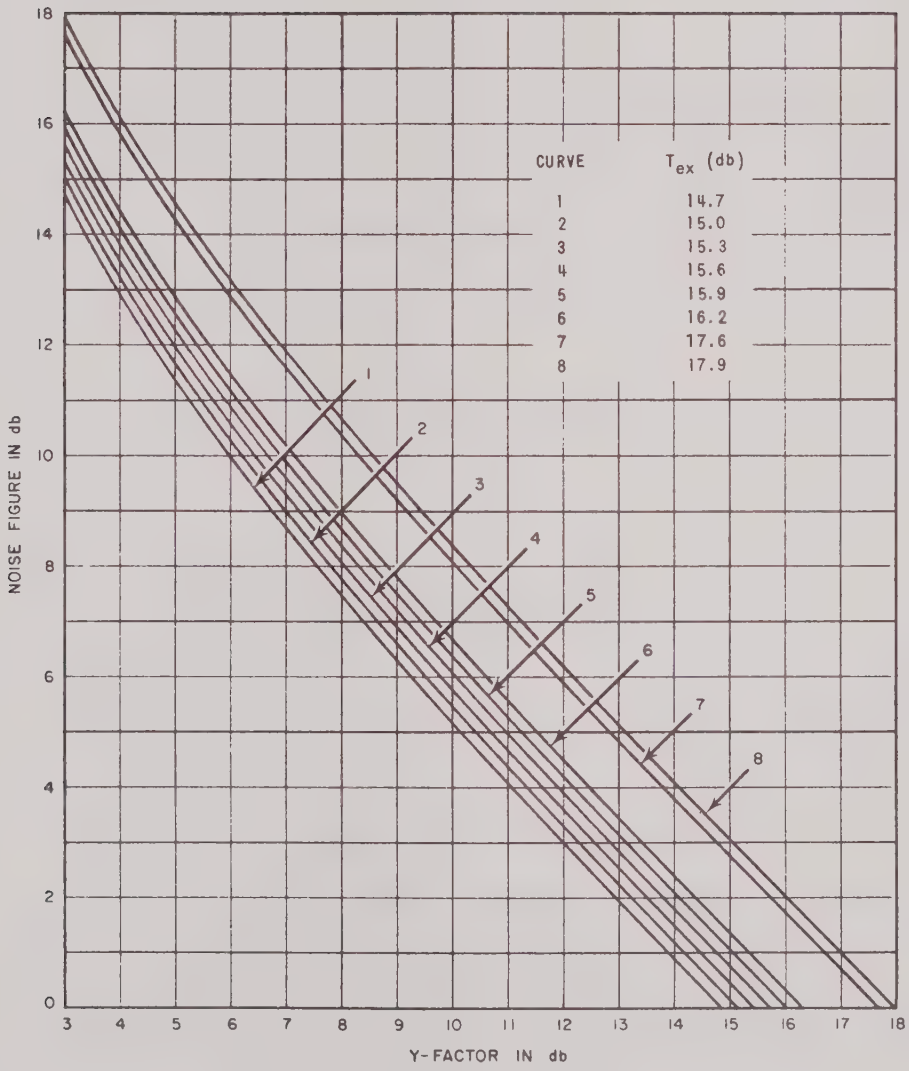


FIGURE 4-11. NOISE FIGURE VS Y-FACTOR FOR VARIOUS DISCHARGE NOISE GENERATORS

SECTION V
THEORY OF OPERATION

5-1 SYSTEM DESCRIPTION

The Type 137 RF Attenuation Calibrator is a highly stable receiver which includes double frequency conversion. The first IF is at 70 MHz (wideband); the second IF is at 30 MHz (narrowband). Basically, however, the receiver system can be divided into two main categories of operation: signal frequency detection and control, and signal amplitude detection and control. Some portions of the system are functionally common to both categories. These include the preamplifier and postamplifier at 30 MHz, the noise generator, and the 1-kHz modulator. A simplified block diagram of the receiver is shown in Figure 5-1.

The heterodyned signal from the RF mixer is at a nominal 70 MHz; the signal is amplified and then linearly converted to 30 MHz. This operation is performed in the first IF preamplifier and IF mixer. The 30-MHz signal is further amplified in the second preamplifier and then square-wave modulated at a 1-kHz rate. The modulated 30-MHz signal is attenuated through a precision waveguide below-cutoff attenuator and then applied to the input of the 30-MHz postamplifier. The output of the noise generator is also applied to the postamplifier input. The noise generator output is basically band limited Gaussian noise. When the attenuator is at its reference setting (0.00 dB), the noise is modulated at a 1-kHz rate. The modulation is in counterphase with the modulation of the preamplifier output. At settings of the attenuator greater than approximately 30.00 dB, the output of the noise generator is applied to the postamplifier without modulation.

When the output level of the noise generator is adjusted according to the procedures described in Section IV, the total noise at the postamplifier input will appear to be unmodulated (attenuator set to 0.00 dB) whereas the IF signal will be square-wave modulated. The "unmodulated" noise and modulated IF signal are amplified in the postamplifier and then detected. The output of the second detector will contain a 1-kHz square-wave signal and noise. This is further amplified in a narrowband 1-kHz amplifier and then coherently detected (REFERENCE NORM) or peak detected (REFERENCE EXP). The detected signal is displayed on a taut band, precision, current meter.

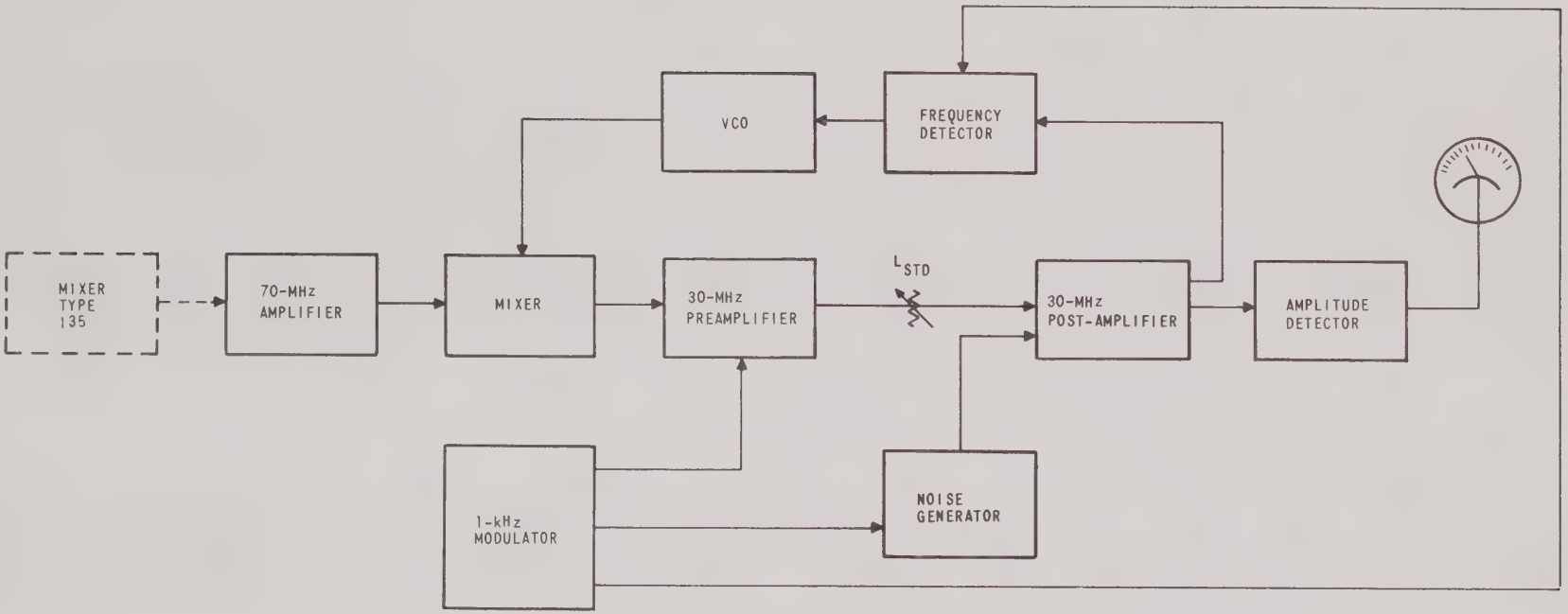


FIGURE 5-1. SIMPLIFIED SYSTEM BLOCK DIAGRAM

Frequency detection and control is an important function of the system. The nominal 70-MHz signal, after being amplified, is frequency converted to the second IF. The second IF is a function of the VCO frequency. The second IF signal is amplified, amplitude modulated, and then applied to a frequency detector. The detector provides a square-wave output whose amplitude is proportional to the difference between the second intermediate frequency and 30 MHz (the frequency detector includes a discriminator which is tuned to 30 MHz).

When the second intermediate frequency is not at 30 MHz, a correction voltage is applied to the VCO. The correction voltage will cause the frequency of the VCO to shift in the direction to minimize the difference between the second IF and 30 MHz. For example, if the first IF is at 71 MHz and the VCO frequency is initially at 100 MHz, there would be a 1-MHz frequency error. However, a correction voltage applied to the VCO will cause the VCO frequency to shift to approximately 101 MHz. Actually there would be a residual error of 500 Hz in the VCO frequency; thus, the second IF signal would be at 30.0005 MHz. The Type 137 System is designed to reduce frequency errors by as much as 2000 to 1.

5-2 SUBSYSTEM DESCRIPTION

5-3 FIRST IF (70 MHz) SUBSYSTEM

The first IF subsystem consists of a 70-MHz amplifier, an RF crystal current monitoring circuit, a 70-MHz bandpass filter, and a diode peak detector. A block diagram of the 70-MHz subsystem is shown in Figure 5-2.

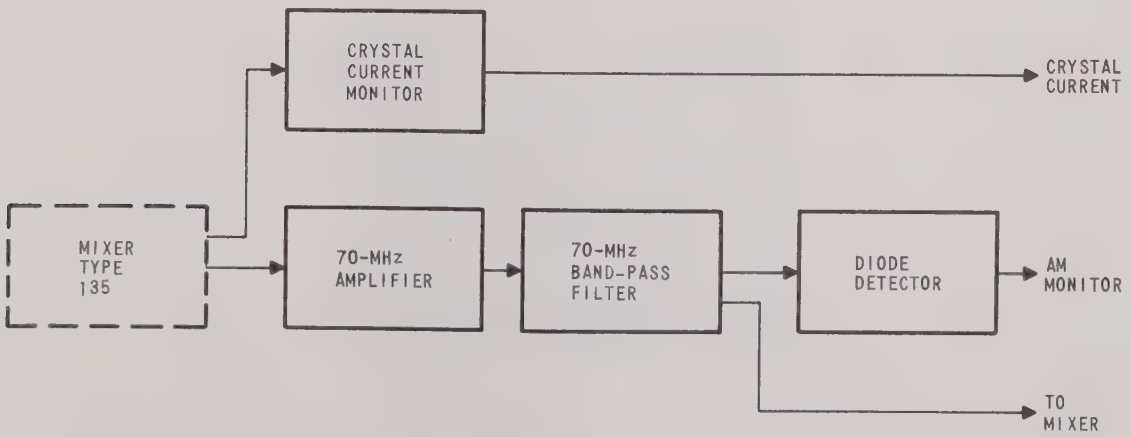


FIGURE 5-2. 70-MHz SUBSYSTEM BLOCK DIAGRAM

The function of this portion of the system is to linearly amplify the IF signal from the RF mixer output. It is extremely important that the amplification be constant over the entire range of input signal levels. Since the RF signal level, at the mixer input, can vary from approximately -15 dBm, the 70-MHz preamplifier has been designed for linear operation up to -21 dBm (a 6-dB mixer conversion loss is assumed).

A bandpass filter has been utilized to provide the selectivity required to attenuate unwanted spurious signals. This is especially important during initial frequency lock-on. A description of this is given in paragraph 4-17. In order to ensure the accuracy of the RF attenuation measurement when frequency drift in the RF source occurs it is necessary to have a flat frequency response in the filter passband.

Figure 5-3 is a photograph of an oscilloscope display of the detected filter output under swept conditions. A flat frequency response has been achieved. The diode peak detector is used as an aid in tuning the filter. It is also used in performing amplitude modulation measurements. The measurement description is given in paragraph 4-34.

The filtering in the RF crystal current monitoring circuit provides isolation between the 70-MHz signal and the crystal current display circuits.

5-4 SECOND IF (30 MHz) SUBSYSTEM

The second IF subsystem consists of a 30-MHz preamplifier, a waveguide below-cutoff precision attenuator, a band-limited Gaussian noise source, a 30-MHz postamplifier, and a second detector.

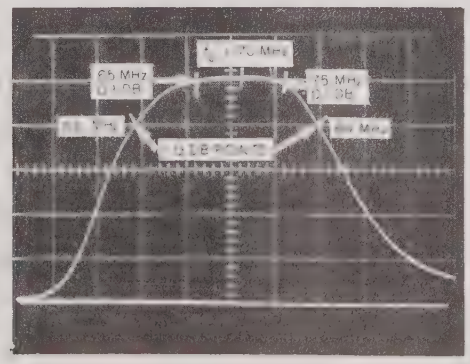


FIGURE 5-3. FREQUENCY RESPONSE OF 70-MHz AMPLIFIER

The functions of this portion of the system are to amplify the IF signal from the IF mixer output, to provide a capability for changing the signal level by a precise increment, and to provide an output signal corresponding to a given input signal level.

The 30-MHz preamplifier linearly amplifies the IF signal from the preamplifier converter. Considerations regarding linearity are quite important for this unit. The amplifier is capable of handling input signals as high as -10 dBm. Having 25 dB of gain, it can provide a linear output of as high as +15 dBm. An electronic switch is included in the amplifier. This enables the output of the amplifier to be 100 percent square-wave modulated.

The 30-MHz postamplifier amplifies the IF signal originating from the mixer output. It includes an adjustable gain control, DETECTOR LEVEL, having at least 50 dB of range. The bandwidth of this unit is approximately 1 MHz. Its bandwidth has been chosen to be narrower than that of the preamplifier preceding it and also less than the bandwidth of the noise generator. Therefore, the postamplifier serves as a "window" for the noise coming from the signal channel and the noise generator. The postamplifier is operated in its linear range when the indicator is adjusted to be in the area marked DET LEV. The reason for adjusting the amplifier gain to a linear range is to avoid saturation at low signal-to-noise ratios. Saturation could result in a change of the noise statistics and thereby introduce an RF attenuation measurement error.

The series IF substitution method for performing RF attenuation measurements requires an attenuation standard at an intermediate frequency. In the Type 137 a precision waveguide below-cutoff attenuator is used as the attenuation standard. The accuracy of this standard can be affected by the impedances which terminate its ports. Thus, this system has been designed so that the attenuator is operated with a matched source and load. TNC connectors are used on the attenuator in order to minimize leakage at the ports and to provide mechanical stability of the electrical connection. This type of connector has extremely low leakage, typically more than 125 dB below the signal power.

The noise stabilization technique extends the RF measurement range of the IF series substitution system. The range is extended primarily because the detected output is unique for a given signal level and gain setting. The uniqueness is due to the fact that the noise level at the detector is constant. The noise level is stabilized at a constant level by the addition of a precise amount of noise power at the postamplifier input. An extremely important consideration, regarding the accuracy of an RF attenuation measurement, is the change of output impedance of the noise generator when it is switched from an on to an off state. A 10-percent change in the impedance of the noise source could introduce a measurement error as large as 0.11 dB. In the Type 137 an impedance adjustment is provided

so that no error occurs when the noise generator is switched. This adjustment can be performed very simply while the system is operating.

5-5 AUDIO SUBSYSTEM

The detected output of the IF postamplifier is further amplified and detected in the audio subsystem and then displayed on a meter or recorder. Figure 5-4 is a block diagram of the audio subsystem.

The 1-kHz amplifier has a square wave input but, due to its narrow bandwidth, has a sine wave output (1-kHz monitor). The dynamic range of this narrowband (150 cycles) amplifier has been designed so that approximately 99 percent of the time noise voltages will not saturate the amplifier. If saturation occurred the noise statistics would change and an error could result.

Either a peak or a coherent detector is used as the system third detector. When the peak detector is used, the REFERENCE EXP switch is depressed; when the coherent detector is used, the REFERENCE NORM switch is depressed. In the EXP mode, the system resolution is typically 0.004 dB per meter scale division. Peak detection is used to aid in achieving a system stability consistent with this resolution. This detector is insensitive to phase changes in the amplifiers and modulating signal.

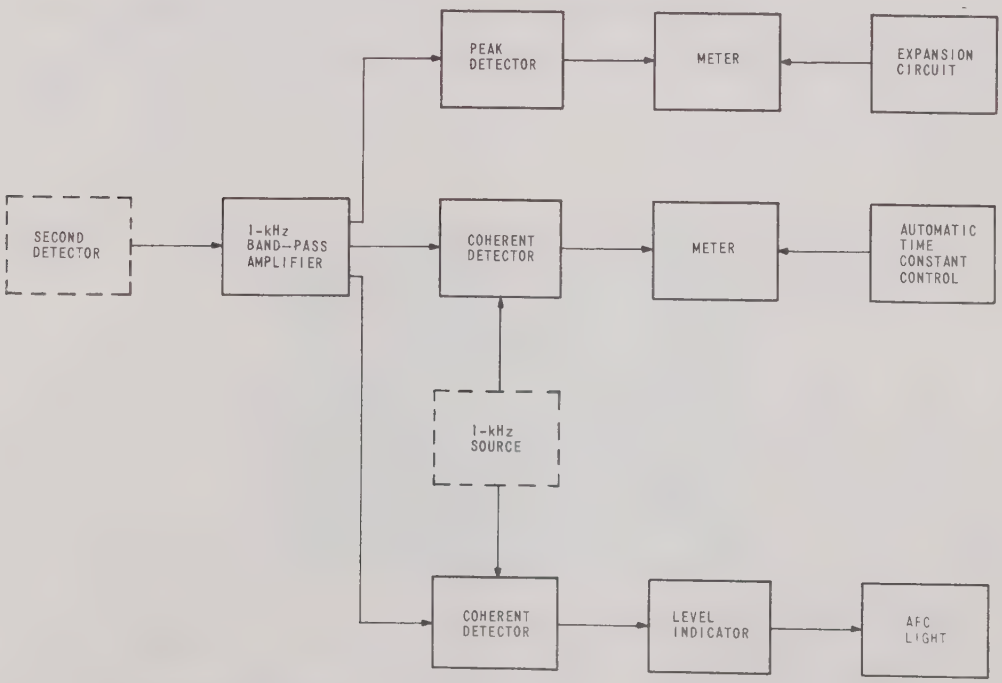


FIGURE 5-4. AUDIO DETECTOR SUBSYSTEM

At low signal-to-noise ratios the resolution deteriorates in the EXP mode. To improve the resolution a coherent detector is used as a third detector. The RF signal level at which the coherent detector would normally be used is -90 to -120 dBm. In addition, the coherent detector is used when setting the level of the internal noise generator. In this case the level is set so that a null is obtained on the meter.

At very low signal-to-noise ratios a large time constant is required. In fact, as the signal level is reduced a larger time constant is desirable. In the Type 137 an automatic time constant control is incorporated. This control is ganged with the audio gain control, so that as the gain is increased the time constant is also increased.

The audio detection subsystem is also used to indicate the presence of a 30-MHz signal. If a signal is present in the 30-MHz subsystem, it is amplified and detected. The detected signal is further amplified and then coherently detected. Coherent detection is utilized since it is capable of producing a detected output proportional to the RF signal even at levels as low as -115 dBm. The output of the detector is fed to a voltage level indicator. If the output is above approximately 10 mV the AFC indicator will light. If a 30-MHz signal is present and the detected output is below 10 mV the indication on the REFERENCE NORM position will be too low to be very useful and therefore the AFC indicator would not light.

5-6 AFC SUBSYSTEM

The automatic frequency control (AFC) loop compensates for frequency drift in either RF source.

The VCO frequency is automatically adjusted such that a 30-MHz intermediate frequency is maintained. The loop can respond to RF signal levels as low as -115 dBm. A block diagram of the AFC loop is shown in Figure 5-5. The amount of correction the loop can provide is derived below.

Referring to Figure 5-6, the mixer output frequency, f_2, in MHz, is:

$$f_2 = f_{VCO} - f_1 \tag{6}$$

Similarly,

$$V_1 = K_2 \left(f_2 - 30 \right) \tag{7}$$

where K_2 is expressed in volts/MHz and,

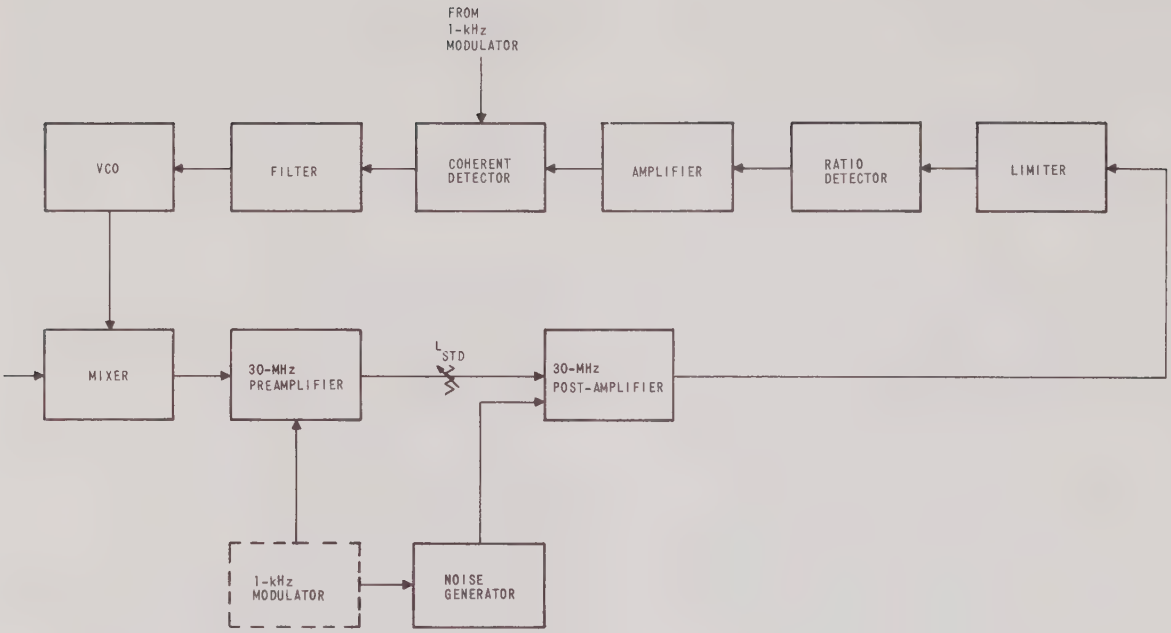


FIGURE 5-5. AFC LOOP BLOCK DIAGRAM

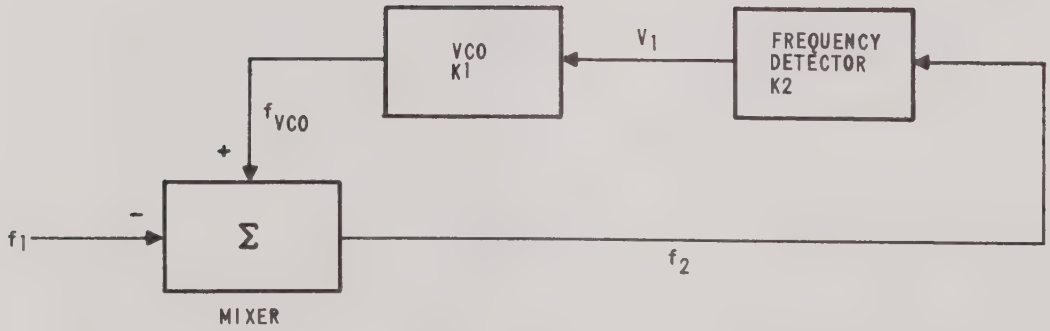


FIGURE 5-6. SIMPLIFIED AFC LOOP

$$f_{VCO} = 100 + K_1 V_1 \tag{8}$$

where K_1 is expressed in MHz/volt

$$f_1 = 70 + \Delta f \tag{9}$$

where Δf is the frequency deviation from a nominal 70 MHz. Substituting equation 7 into 8 we have,

$$f_{VCO} = 100 + K_1 K_2 \left(f_2 - 30 \right) \tag{10}$$

Substituting equations 10 and 9 into 6 and solving for f_2 we have,

$$f_2 = 30 \frac{\Delta f}{1 - K_1 K_2} \tag{11}$$

The open loop gain $K_1 K_2$ in the Type 137 is approximately 2500. The VCO sensitivity, K_1, is approximately 2 MHz/volt and the gain, K_2, is approximately 1250 volts/MHz. Since the loop gain is so large it can be seen from equation 11, frequency drift, Δf, of either RF generator can be reduced by a factor of 2500.

At low signal-to-noise ratios the Type 137 has been designed so that K_2 decreases in value as the signal-to-noise ratio decreases. This aids the AFC loop to remain locked when the RF signal level is as low as -115 dBm.

Referring to Figure 5-5, the output of the ratio detector is a square wave whose amplitude is proportional to the frequency difference between the second IF and 30 MHz. The phase of the square wave jumps 180 degrees when the IF frequency passes through 30 MHz. A photograph of the ratio detector output is shown in Figure 5-7.

The filter preceding the VCO has a dual function. It ensures that the loop is stable under all operating conditions and secondly, it minimizes the noise voltages which modulate the VCO at very low signal-to-noise ratios. As a result of this filter, the loop can only respond to slow frequency changes which could cause errors in attenuation measurements.

Two additional considerations regarding the loop performance are the capture range and hold-in range. The capture range is a description of a prelock characteristic and the hold-in range describes a postlock characteristic. The capture range is determined

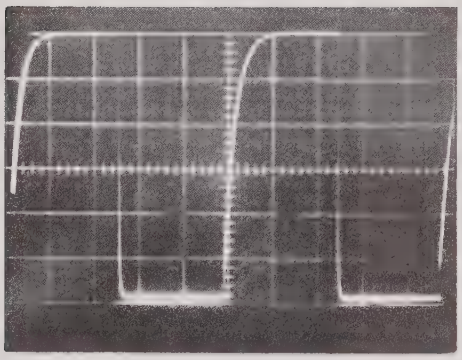


FIGURE 5-7. RATIO DETECTOR OUTPUT

by the bandwidth of the second IF amplifier and is typically 3 MHz. The hold-in range is determined by the bandwidth of the first IF amplifier and is typically 35 MHz. At low signal-to-noise ratios the ranges are reduced.

A Search-Lock capability is provided to simplify the problem of setting the frequency of the RF generators. When the Search-Lock High button is depressed and released, a scanning voltage is temporarily fed to the VCO. The applied voltage starts at 35 volts and decays to approximately 10 volts, the VCO resting voltage. The VCO scanning range in this mode is approximately from 120 to 100 MHz. If an IF signal in the range of approximately 70 to 90 MHz is present at the preamplifier-converter input, the AFC loop will lock as the VCO frequency approaches within 30 MHz of the IF signal frequency. The green AFC indicator will illuminate.

Similarly, when the Search-Lock Low button is depressed and released, a scanning voltage starting at zero volts is applied to the VCO. This voltage rises to approximately 10 volts. The VCO scanning range in this mode is approximately from 85 to 100 MHz. If an IF signal in the range of approximately 55 to 70 MHz is present at the preamplifier-converter input, the AFC loop will lock as the VCO frequency approaches within 30 MHz of the IF signal frequency.

When the AFC loop locks, the VCO voltage will remain at the value required for the VCO frequency to be 30 MHz away from the input IF frequency. After the loop is locked, it is good practice to adjust the frequency of the RF local oscillator so that the VCO voltage will be approximately 10 volts. This ensures that the VCO is at the center of its hold-in range and therefore greater range of RF frequency drift would be accommodated.

A feature of the AFC loop, when RF attenuation measurements are performed, is that it will lock on either the upper or lower sideband of the RF mixer output. As a result it is not necessary for the operator to calculate or experiment to determine the phasing or sideband required to achieve lock. In most conventional single frequency conversion systems this is necessary.

5-7 SUBASSEMBLY DESCRIPTION

5-8 CHASSIS

The schematic diagram for the Type 137 receiver is shown in Figure 5-8. This diagram shows the interconnections between the various subassemblies and chassis components.

The DC power for the preamplifier-converter and the RF mixer crystal current are filtered through a double Pi section filter. This filtering plus the shielding of the power cable tends to minimize any external signal leaking into the receiver. Figure 5-9 is a schematic of the filter assembly.

As a further precaution against signal leakage and coupling, each subassembly is connected to the +40 VDC supply through a separate shielded cable. The connections are made to TB901 and are shown in the schematic.

To minimize leakage within the receiver each subassembly is encased in a shielded enclosure and positioned so that the high and low signal power connections and cables are isolated.

The Type 137 can be used with a nominal line voltage of either 115 or 230 VAC. All models sent from the factory are connected for 115 VAC operation unless otherwise requested. To change from 115 to 230 VAC, it is necessary to reconnect the jumper wires on TB902 as shown in the schematic.

A transformer T901 converts the line voltage to 6.3 VAC. This voltage is used to provide power for the meter lights DS902, 3, 4, and 5. It is also used to obtain -13 volts from the voltage doubler consisting of C903, CR902, CR903, and C904.

Two Pi section filters consisting of C907, C901, C909, C908, L902, and C910 provide filtering of the AC line against unwanted IF and RF signals.

The output indicator of the Type 137 RF Attenuation Calibrator is meter M901, whose function is controlled by switch S901. When S901 is in crystal 1 or 2, the meter and its multiplier resistor R803 are placed across one of two 100-ohm current-sampling

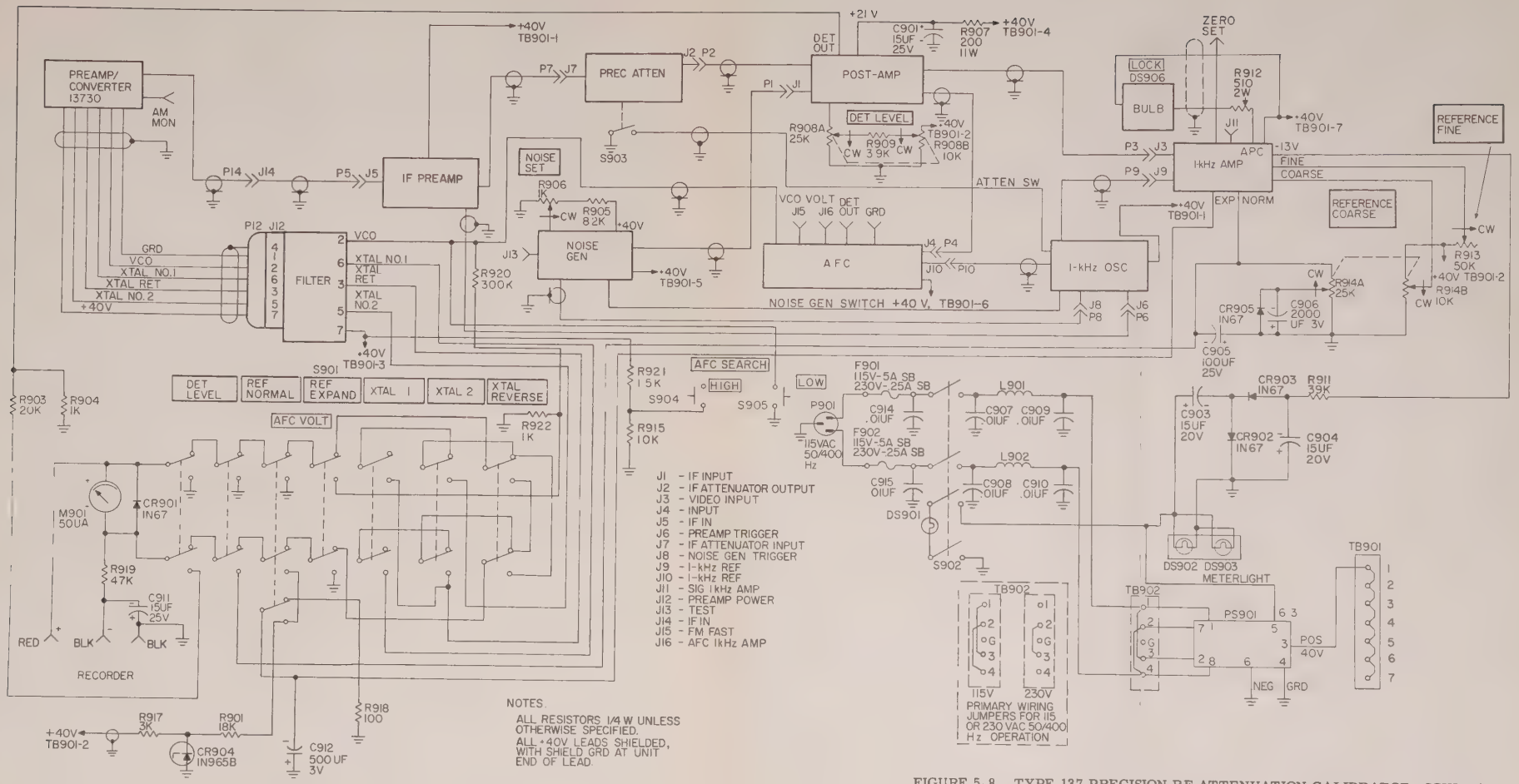
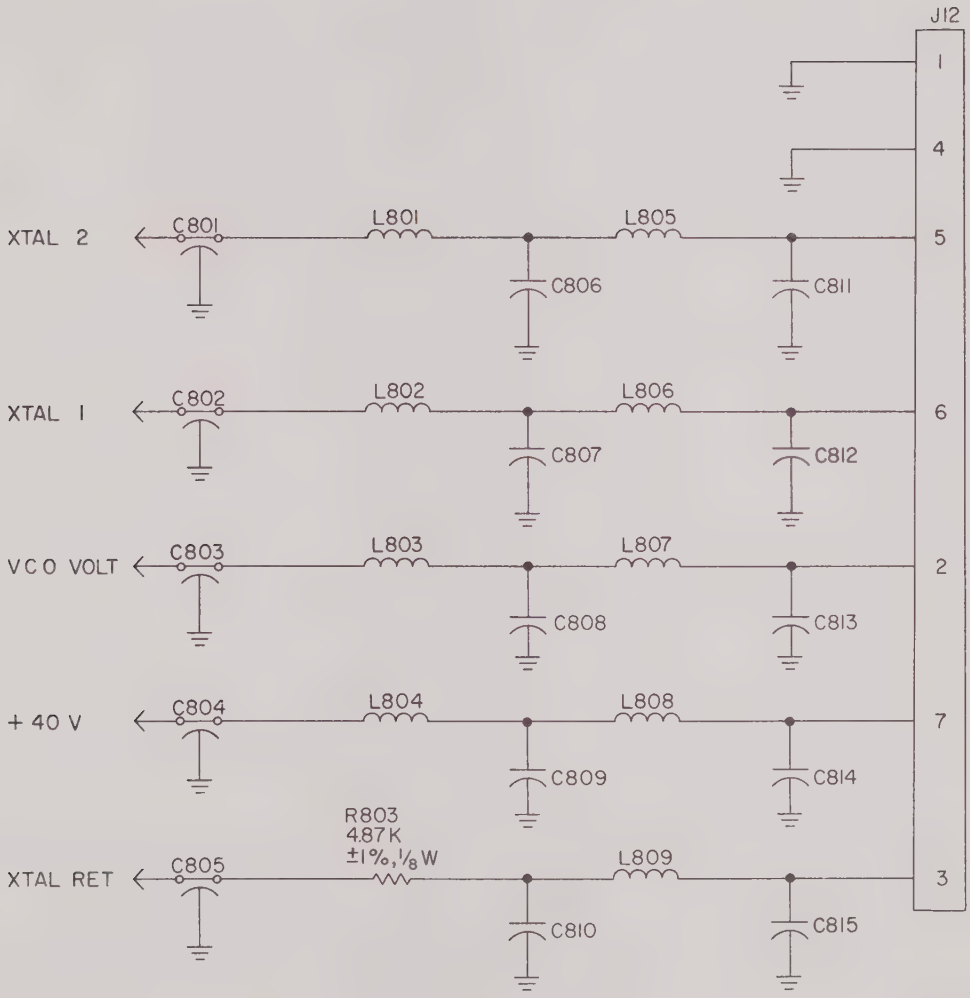


FIGURE 5-8. TYPE 137 PRECISION RF ATTENUATION CALIBRATOR, SCHEMATIC

FIGURE 5-8



UNLESS OTHERWISE NOTED
1- ALL CAPACITORS 1000 PF
2- ALL INDUCTORS 1.1 UH

FIGURE 5-9. FILTER SCHEMATIC

resistors in the preamplifier-converter. The full scale range of the meter in this mode corresponds to 3 mA of crystal current. Polarity is reversed by depressing the REVERSE switch.

When S901 is in DETECTOR LEVEL position, the postamplifier detector current is applied to the meter through resistors R903 and R904, which make up a 20-to-1 attenuator. The basic meter movement is 50 μA full scale.

When S901 is in REFERENCE NORM position, the 1-kHz amplifier coherent detector output is applied to the meter. Variable resistor R914A, C905, C906, and CR905 provide a variable time constant for observing the output indication.

When S901 is in REFERENCE EXP position, the peak detector output of the 1-kHz amplifier is applied to the meter. Simultaneously, a bucking current obtained from the 40V line and attenuated by R917, CR904, and R901 is also applied to the meter. Extremely good resolution, typically 0.004 dB per scale division, is obtained. Resistor R918 and capacitor C912 provide a fixed time constant for the meter in the expand mode.

The AFC indicator, mounted on the front panel, illuminates when the voltage level indicator in the 1-kHz amplifier has a sufficient input signal. The bulb DS906 operates on approximately 40 mA. Resistor R912 is a current limiting resistor.

Resistor R906 is a variable gain control for the amplifier in the noise generator. A clockwise rotation of this 10-turn potentiometer will reduce the noise output.

Resistor R908A and B is a variable gain control for the 30-MHz postamplifier. A clockwise rotation increases the gain of this unit.

Resistors R915 and R914B provide a variable coarse gain control for the 1-kHz amplifier. A clockwise rotation increases the gain.

A variable fine gain control is provided by resistor R913. A clockwise rotation increases the gain.

5-9 PREAMPLIFIER CONVERTER

A block diagram of the preamplifier-converter is shown in Figure 5-10 and a schematic of the unit is shown in Figure 5-11. This unit includes a wideband amplifier, a bandpass filter, a broadband mixer, and a voltage-controlled local oscillator.

The input of the amplifier is designed to mate with the AIL Type 135 mixers. Two gold-plated beryllium copper clips, mounted on the amplifier printed-circuit board, accept the pin output of the double-ended balanced mixers. A variable inductor, L701,

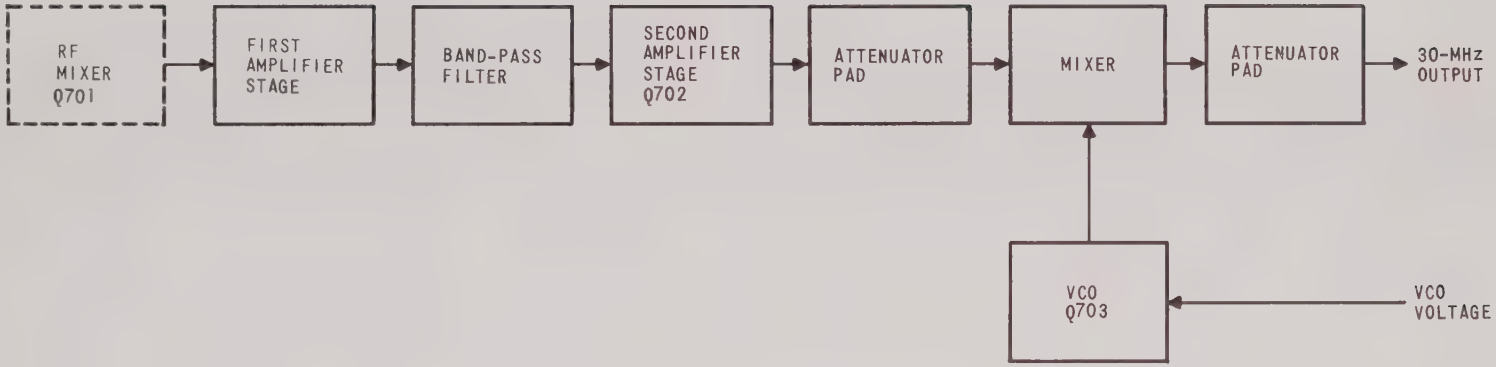
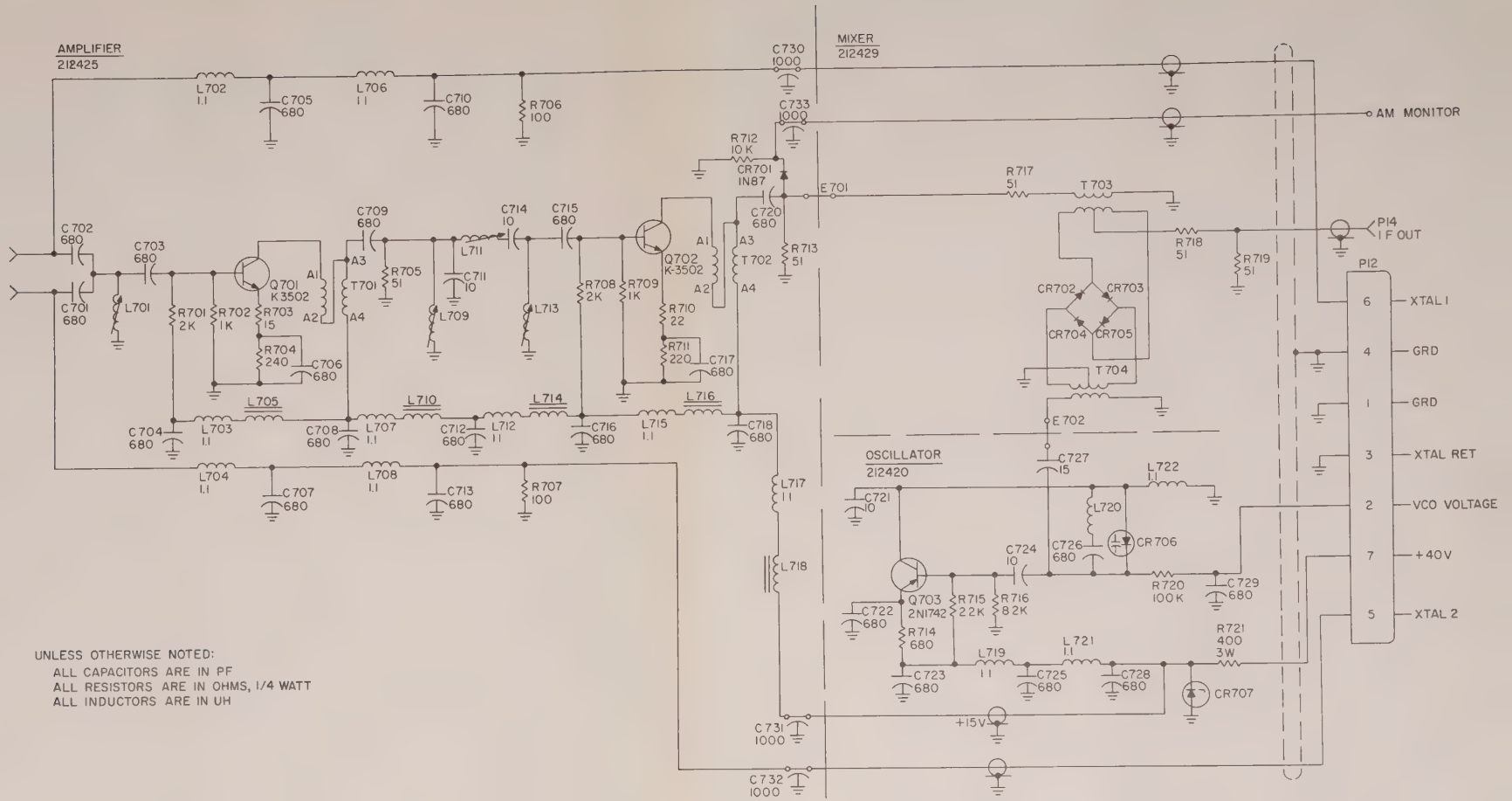


FIGURE 5-10. PREAMPLIFIER-CONVERTER, BLOCK DIAGRAM



UNLESS OTHERWISE NOTED:
ALL CAPACITORS ARE IN PF
ALL RESISTORS ARE IN OHMS, 1/4 WATT
ALL INDUCTORS ARE IN UH

FIGURE 5-11. PREAMPLIFIER-CONVERTER SCHEMATIC

provides matching of the output impedance of the mixer to the input of the amplifier in order to achieve a good front end noise figure. The preamplifier consists of two stages of amplification and has a nominal 100-MHz 3-dB bandwidth. The broad bandwidth is obtained through the use of toroidal transformers and high frequency transistors, KMC K3502.

An interstage bandpass filter provides selectivity. It has a center frequency of 70 MHz and provides the amplifier with a bandwidth of 10 MHz with less than 0.1 dB of ripple and a 20-MHz bandwidth with less than 0.5 dB of ripple. The filters consist of L709, L711, L713, C714, and C711.

The pads inserted before and after the mixer provide a good impedance match over a 20-MHz band. As a result of the impedance match, the conversion loss of the mixer is flat within 0.03 dB over the frequency range of 65 to 75 MHz. The mixer is doubly balanced and consists of a matched diode quad CR702, CR703, CR704, and CR705 and wideband transformers T701 and T702. The mixer provides high isolation between the signal, local oscillator, and IF ports.

The voltage-controlled oscillator is used as a local oscillator for the mixer. It provides an output of +5 dBm over its entire frequency range. The oscillator is a one-stage, 2N1742, feedback amplifier. The frequency of oscillation is primarily determined by L720 and the varactor diode, CR706, capacitance. Since L720 is fixed, tuning of the oscillator is accomplished by changing the reverse bias on the varactor diode.

The stability of the preamplifier converter is enhanced by the voltage regulation of zener diode CR707. Resistor R721 is a voltage-dropping resistor for the diode.

5-10 30-MHz PREAMPLIFIER

A block diagram of the 30-MHz preamplifier is shown in Figure 5-12 and a schematic is shown in Figure 5-13. This unit includes a three-stage amplifier and an electronic switch.

The overall power gain of this unit is about 22 dB for signal levels up to -7 dBm input. All stages are synchronously tuned to 30 MHz by means of variable inductors. Interstage coupling is provided by means of capacitive divider networks. The overall amplifier bandwidth is approximately 2.5 MHz.

The input signal to the preamplifier is obtained from the output of the IF mixer. Since a 3-foot length of 50-ohm coaxial cable connects the two units, it is very desirable to have a 50-ohm input impedance looking into the preamplifier. The matching network consisting of C202, C204, L201, and C205 transform the amplifier input impedance to 50 ohms.

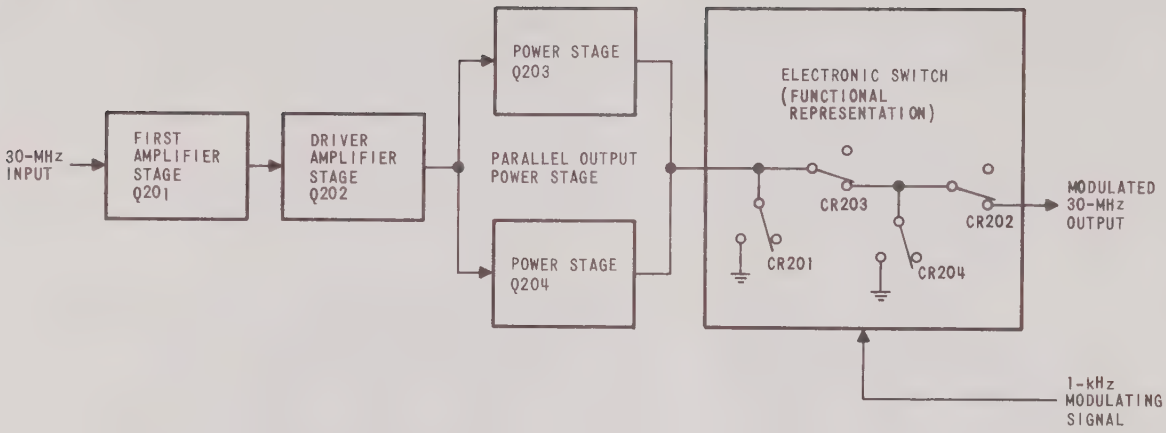


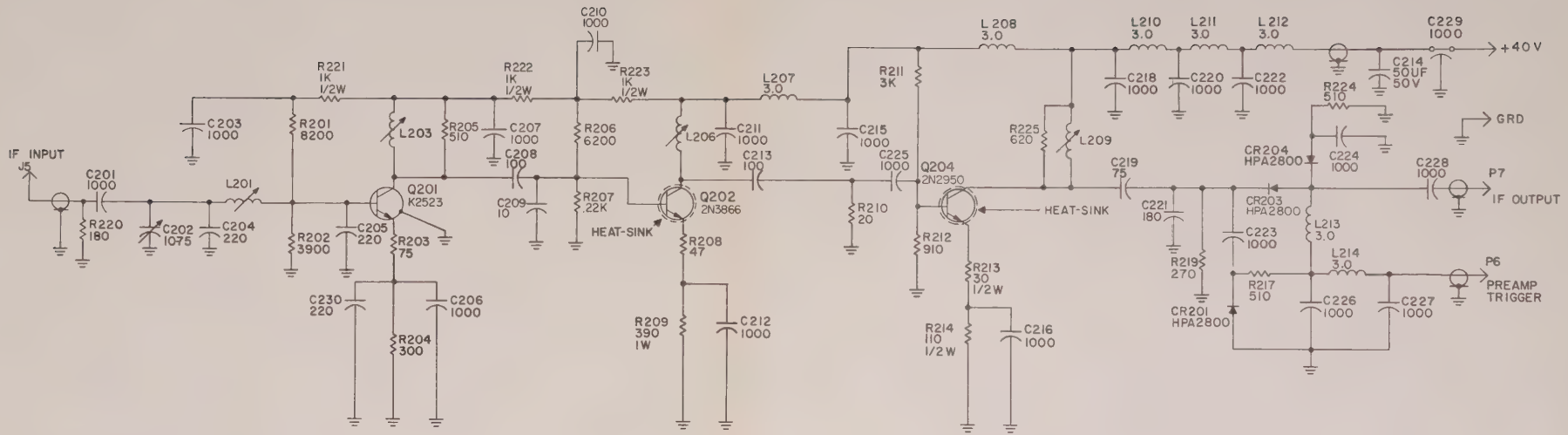
FIGURE 5-12. 30-MHz PREAMPLIFIER BLOCK DIAGRAM

The input stage incorporates a KMC K2523 transistor which is optimized for low noise at high currents. Current feedback through resistor R203 provides linear and stable gain for signal levels as high as -7 dBm input.

The second stage incorporates a power transistor 2N3309, which serves as a driver for the output stage. This stage is optimized for linear amplification and contains current feedback through resistor R208.

The output stage consists of two parallel-connected 2N2950 power amplifiers. Inductor L209 and capacitors C219 and C221 comprise the tank circuit and also provide a 50-ohm impedance match looking from the output connector.

Modulation of the IF signal is accomplished by the opening and closing of the electronic switch consisting of diodes CR201, 202, 203, and 204. Capacitors C224, C226, and C227 provide an RF bypass to ground. Capacitors C223 and C228 provide coupling. A 1-kHz square-wave signal is fed into the "Pulse In" port and turns the switch on when the signal is positive (diodes CR202 and CR203 conduct). When the signal is negative CR201 and CR204 conduct and turn the switch off. PIN type diodes are used in the switch. These diodes exhibit very little capacitance when reverse biased thus high isolation can be achieved. The switch has approximately 70 dB of isolation in the off state.



UNLESS OTHERWISE NOTED:

RESISTANCE VALUES ARE IN OHMS ± 5%, 1/4 WATT
CAPACITANCE VALUES ARE IN PF
INDUCTANCE VALUES ARE IN UH
VARIABLE INDUCTANCE VALUES IN UH AS FOLLOWS:

L201	0.30 - 0.50
L203	0.45 - 0.75
L206	0.30 - 0.50
L209	0.30 - 0.50

568

FIGURE 5-13. IF PREAMPLIFIER SCHEMATIC

FIGURE 5-13

5-11 PRECISION ATTENUATOR

The precision attenuator used in the 137 RF Attenuation Calibrator consists of a cylindrical cavity whose diameter is such that it forms a waveguide well below cutoff at the 30-MHz operating frequency. The launch coil is part of a piston that travels in an axial direction in the waveguide. This coil is tuned by a series capacitor, and the tuning elements are loaded with a series resistor to provide the proper input impedance.

The receiving coil is fixed at the opposite end of the waveguide. This coil is also tuned with a series capacitor and loaded with a series resistor, thus providing the 50-ohm output impedance.

True wave propagation does not exist in a waveguide below cutoff. The fields are exponentially attenuated down the length of the waveguide with a rate of attenuation that is determined by the transmission mode. For any single mode, the attenuation (in dB) is a linear function of the length of the waveguide.

The effective length of the waveguide can be changed by varying the separation between the coils. Thus, for a particular mode, the attenuation (in dB) can be read directly from the linear counter dials.

The primary transmission mode of the precision attenuator used in the Type 137 RF Attenuation Calibrator is a TE_{11} mode. This is the lowest mode that will propagate in a circular waveguide; it also has the lowest attenuation constant. If other modes are generated and propagate down the waveguide, they are attenuated faster than this primary mode of transmission.

If the separation between the two coils were reduced to where coupling to the spurious modes is significant, the linearity of the attenuation (in dB) versus distance characteristic of the attenuator would be affected. Consequently, in a practical device of this sort, it is necessary to provide a minimum separation between the radiating and receiving coils and, thus, preserve the accuracy of the attenuator.

This separation naturally introduces a fixed attenuation between the input and output of the precision attenuator which is called the minimum insertion loss of the device. Careful design of the radiating and receiving coils and selection of an optimum waveguide diameter allow such close coupling that the precision attenuator in the Type 137 exhibits a minimum insertion loss of 18 dB.

A limit switch is mounted on the attenuator. It is actuated when the piston has traveled a distance corresponding to approximately a 30-dB change from the 0.00 dB setting.

When the switch is closed, it actuates a relay which causes the noise generator to operate continuously, that is, no modulation of its output. The relay is actuated by positive 40 volts.

5-12 NOISE GENERATOR

A block diagram of the noise generator is shown in Figure 5-14 and a schematic is shown in Figure 5-15. This unit includes a three-stage amplifier, an electronic switch, and a fixed pad.

The noise generator is basically an amplifier whose input is terminated in a resistive load, R501. The three stages of amplification employ 2N1742 transistors and are synchronously tuned by varying L501, L504, and L507. Feedback of the first two stages is employed to improve the stability of the noise output. Control of the noise output level is achieved by varying the current through the load diodes CR501 and CR507. The current is varied by adjusting the potentiometer, R906, on the front panel (NOISE SET). As a further means for stabilizing the noise output, a zener diode regulator is used in conjunction with the highly regulated system power supply.

The electronic switch consists of diodes CR502, 503, 504, and 505. Capacitors C523 and C524 provide coupling and C517, C528, and C529 provide bypassing of the IF signal to ground. A positive 1-kHz modulating signal will cause diodes CR503 and CR505 to conduct and therefore open the switch. A negative signal will cause diodes CR502 and CR504 to conduct and therefore close the switch. PIN diodes are utilized because of their very small back-bias capacitance.

A variable resistor R516 and a pad consisting of R520 and R519 provide isolation and matching of the noise generator. Resistor R516 is adjusted so that the output impedance of the noise generator is constant regardless of the position of the switch. The impedance is adjusted for a maximum change of VSWR of less than approximately 1.02 to 1. The adjustment technique, which is quite simple, is described in the maintenance section. The function of R520 and R519 is to damp any impedance variations which may occur due to aging or any other affect.

5-13 POSTAMPLIFIER

A block diagram of the postamplifier is given in Figure 5-16 and a schematic is given in Figure 5-17. This unit includes a five-stage amplifier, a second detector, a limiter, and a video and IF emitter follower.

The postamplifier is synchronously tuned to 30 MHz and has a bandwidth of approximately 1 MHz. The postamplifier gain is about 100 dB maximum from the IF input

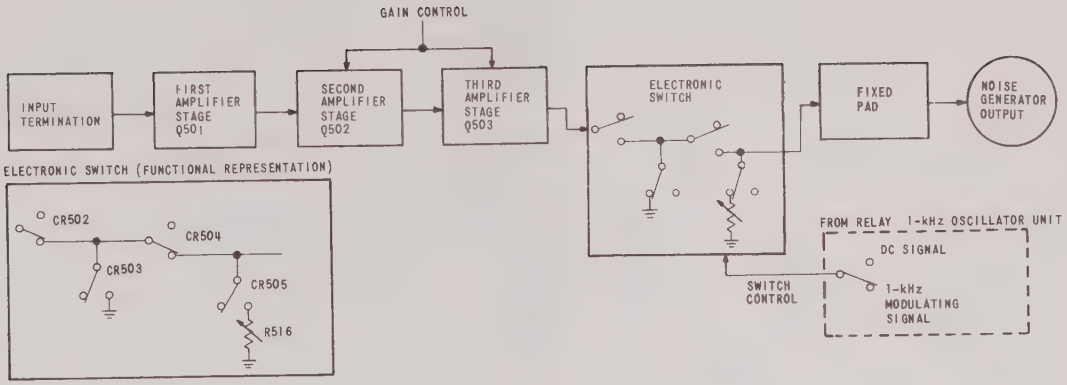


FIGURE 5-14. NOISE GENERATOR BLOCK DIAGRAM

to the second detector input. The input impedance is well-matched, a VSWR of less than 1.3 to 1. The noise figure is typically 7.0 dB.

The first stage utilizes a 2N2996 transistor, Q1. This transistor has a very good low-noise and high-gain characteristic. The input matching network is a Pi configuration consisting of C1, C2, and C3 and L1.

The intermediate amplifier stages utilize 2N2996 transistors Q2, Q3, and Q4. Interstage matching is accomplished by using Pi capacitive divider networks. Each stage is tuned by a variable inductor in the collector circuit. The load for each stage consists of a damping resistor and the input impedance of the following stage transformed by the Pi network. The second and third stages are gain controlled by means of diodes which load the collector circuit. As the DC control current through the diodes is increased the loading increases and the amplifier gain decreases. The diodes are HPA 3039 PIN type. Current control through the diodes is accomplished by varying resistors R903 and R904 on the front panel (DET LEVEL). A dual potentiometer is used to enable the gain control to be a linear function of dial position.

The final amplifier stage utilizes a 2N1141 high-frequency power transistor, Q5. The maximum linear output power of this stage is approximately +3 dBm. Coupling to the second detector and IF emitter follower is through the high-Q Pi network consisting of C27, C28, and L12.

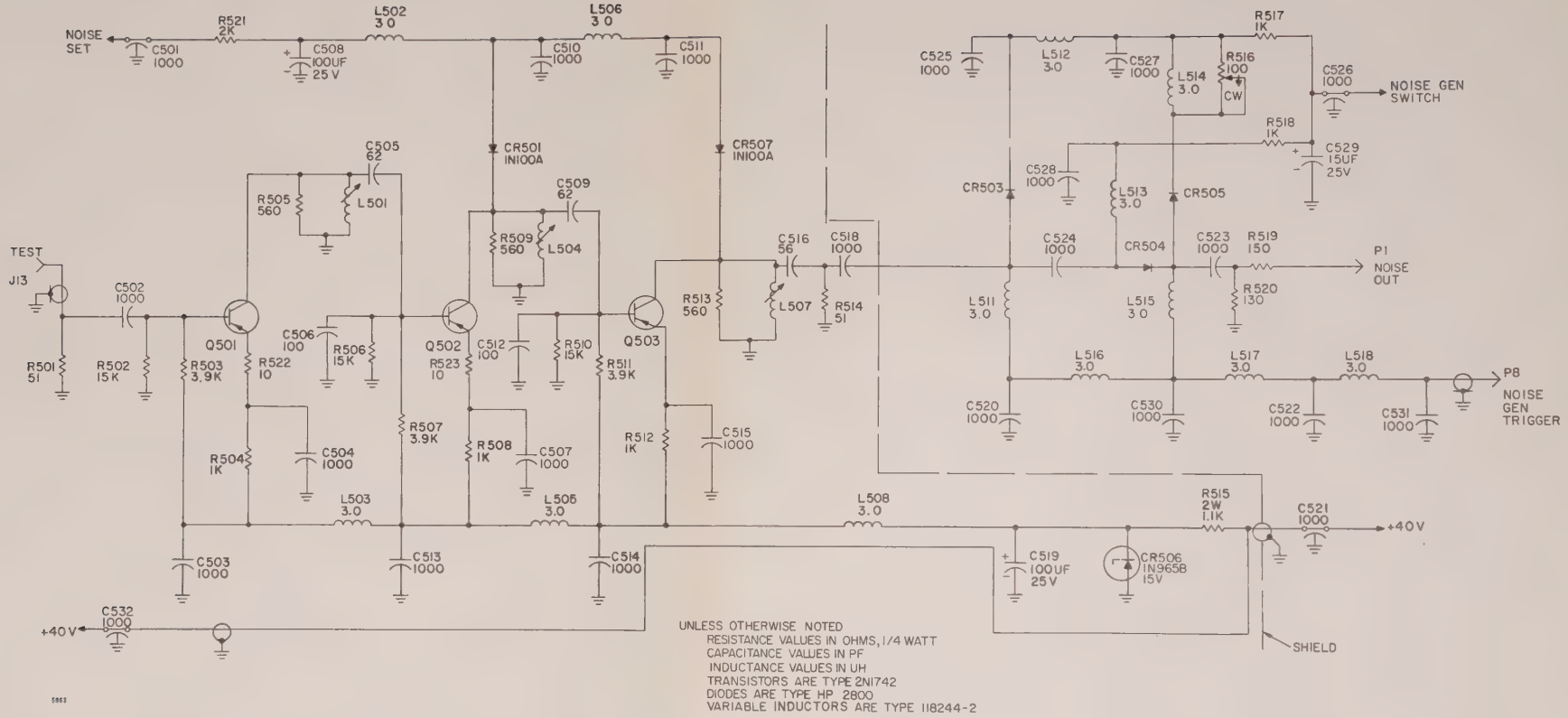


FIGURE 5-15. NOISE GENERATOR SCHEMATIC

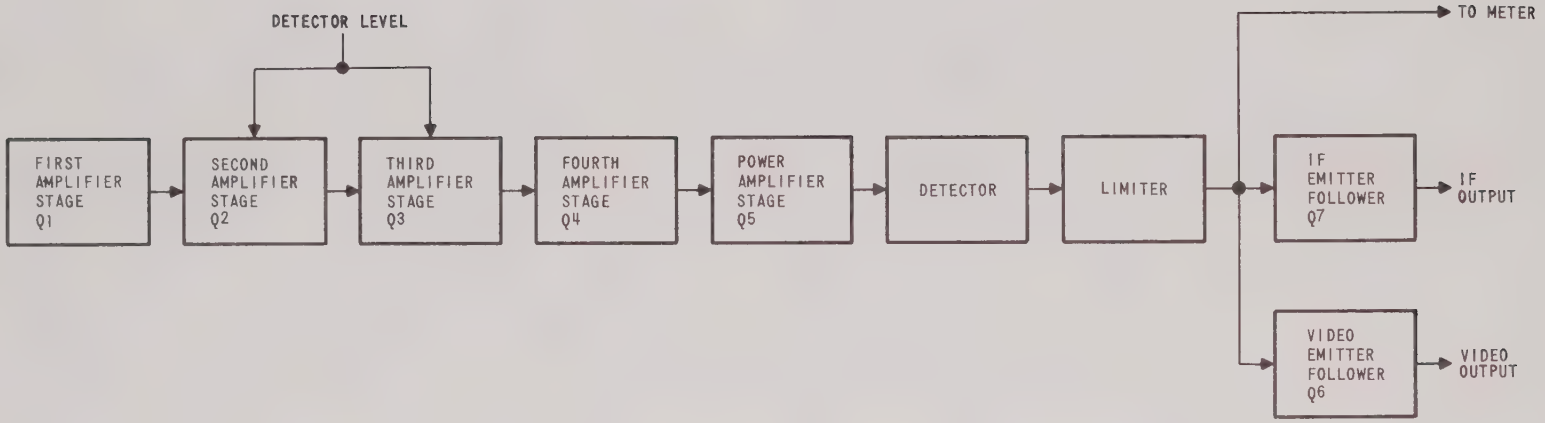


FIGURE 5-16. POSTAMPLIFIER BLOCK DIAGRAM

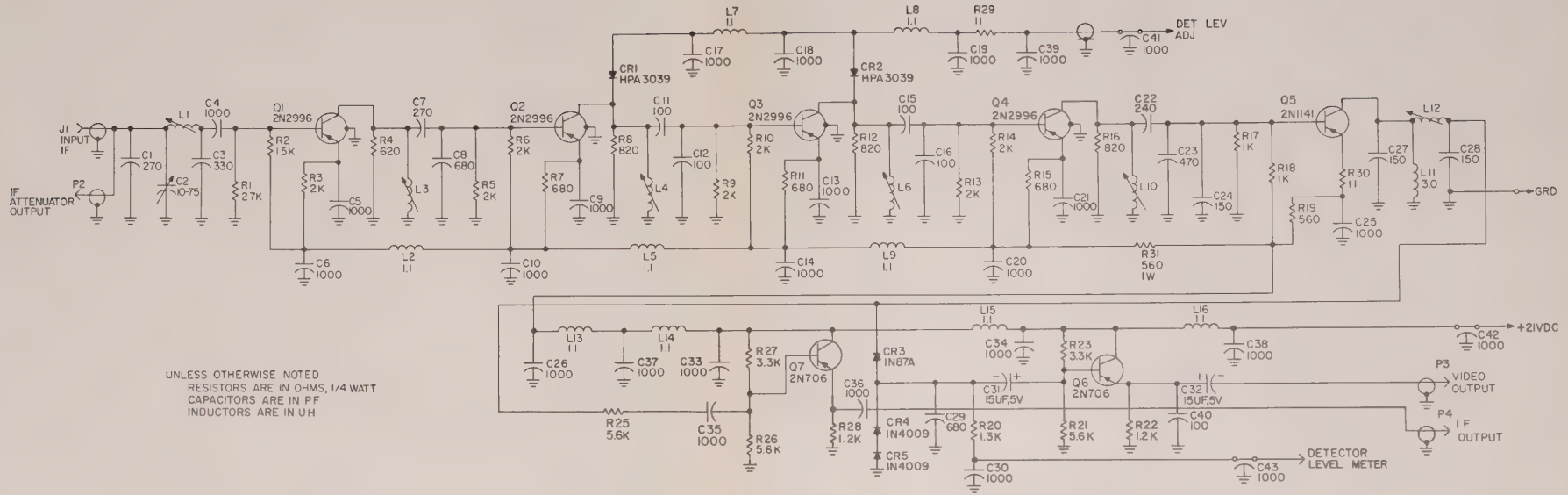


FIGURE 5-17. POSTAMPLIFIER SCHEMATIC

FIGURE 5-17

The second detector is a simple envelope detector consisting of CR3, a 1N87A germanium diode. Capacitor C29 is the detector filter capacitor, which is loaded by series resistor R20, the display circuits, and the limiter.

The limiter consists of two diodes CR4 and CR5, the combination shunting the second detector output. The limiter functions as an overload maximum voltage control device. In RF attenuation measurements the postamplifier is overloaded when the unknown is removed from the system. The amplifier and limiting diodes provide 100 dB of overload protection.

The emitter follower outputs for the IF and video provide a low impedance output and act as a buffer stage between the postamplifier and AFC and audio units.

5-14 AFC DETECTOR

A block diagram of the AFC detector is shown in Figure 5-18 and a schematic is shown in Figure 5-19. This unit includes a limiter, a ratio detector, a 1-kHz amplifier, a coherent detector, and a DC amplifier.

Three stages of limiting are provided in order to ensure "hard limiting" of the IF signal before it is frequency detected. Limiting first occurs in the third stage Q403, then the second Q402, and finally the first stage Q401. This high degree of limiting is necessary because when performing RF attenuation measurement the signal level can change by as much as 100 dB.

After limiting, the signal is frequency detected in a ratio detector. The ratio detector was first described by Seeley and Avins in the RCA Review, approximately 1938. The detector diodes are CR409 and CR410. Inductor L409 tunes with capacitor C423; its value determines the center frequency of the discriminator. Capacitor C422 is used to balance the stray capacity in the circuit. The high output impedance of the detector is transformed down by an FET source follower. Observation of the output of the source follower is accomplished by connecting an oscilloscope to the rear panel BNC output. Incidental FM of the IF signal can be observed at this point. The IF signal applied to the input of the frequency detector is 100-percent square-wave modulated. Thus, for half the modulating cycle the signal is present and for the other half it is not. If a frequency offset exists in the second IF, the output of the ratio detector will be a 1-kHz square wave. The amplitude of the square wave will be proportional to the amount of frequency offset.

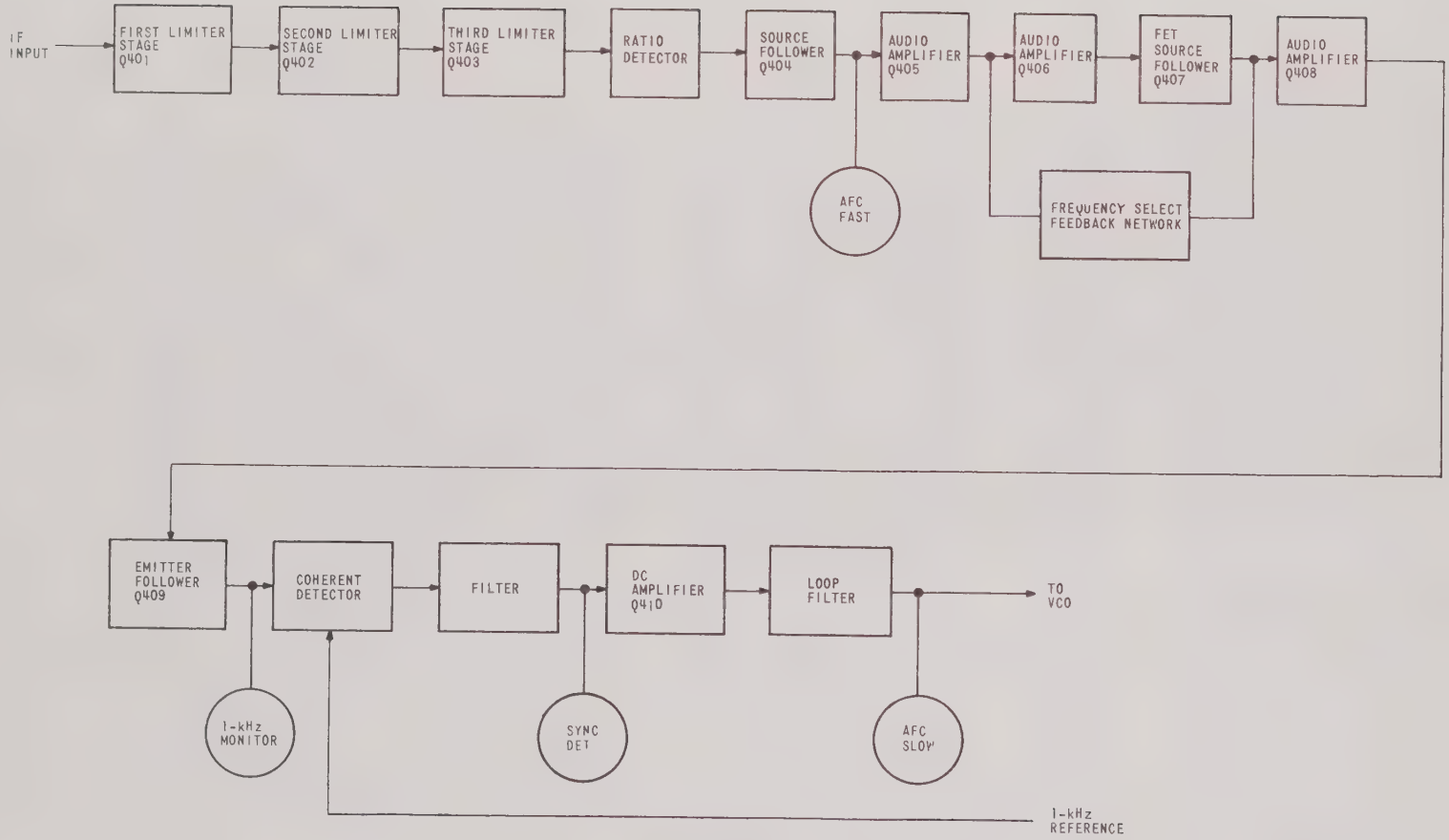


FIGURE 5-18. AFC DETECTOR BLOCK DIAGRAM

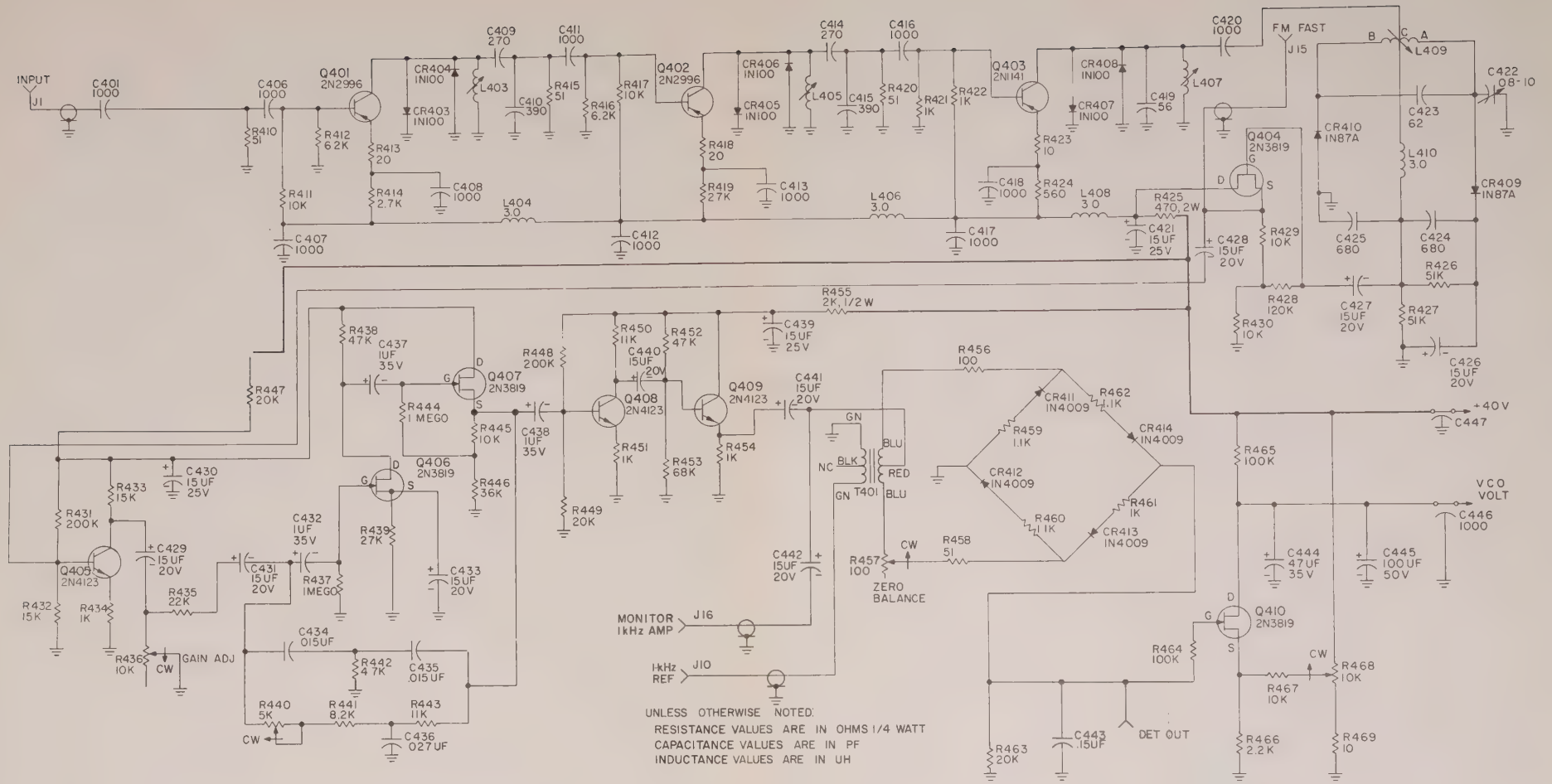


FIGURE 5-19. AFC DETECTOR SCHEMATIC

FIGURE 5-19

The square-wave output of the source follower is amplified in three successive stages of amplification. The first, Q405, is provided with an internal gain control, R436. This control is adjusted for an overall frequency detector characteristic of approximately 1200 volts/MHz.

The second stage of amplification includes an FET amplifier, Q406, and source follower Q407. A frequency selective feedback network connects the output of the follower to the amplifier input. This network consists of C434, C435, C436, R440, R441, R442, and R443. Resistor R440 is used to adjust the center frequency of the tuned amplifier. The feedback network is a null network; therefore at the null frequency the amplifier gain will be a maximum since no feedback will exist. At frequencies other than at the null, feedback is present and therefore the amplifier gain is reduced.

The third stage of amplification is provided by Q408. Negative current feedback is obtained through resistor R451. The output of this stage is fed to an emitter follower. The follower is utilized as a driver for the coherent detector.

A 1-kHz signal is applied to the coherent detector. This signal is used as reference for comparison with the signal fed from the driver stage Q409. The reference signal causes the diodes CR411, CR412, CR413, and CR414 to conduct on alternate half-cycles. This signal is applied to the diodes through the primary of T401. The resistor in series with the diodes damp the variances in the diode resistance characteristics. Resistor R457 is used for balancing the reference signal drive at the secondary of the transformer.

The detector output will have an average or DC output when the signal from the driver amplifier is applied to the detector and when the phase difference between it and the reference signal is not 90 degrees. A maximum output, for a given input, will occur when the signal is in phase with the reference signal. Since the reference signal and amplified signal are derived from the same source, the 1-kHz oscillator, these two signals will be in phase. The advantage of using the coherent detector is that at low signal-to-noise ratios the detector will discriminate against the noise. The detector DC output will be proportional to its input signal. Noise at the input does not result in an average detector output because the noise is uncorrelated with the reference signal phase.

The output of the coherent detector is amplified in the DC amplifier, Q410. This amplifier provides sufficient drive signal to enable the VCO to assume its complete frequency range capability. Resistor R468 is a bias control which is set so that for 0 volt DC input the drain quiescent voltage is approximately 10.0 volts. Since this quiescent voltage is a bias for the varactor diode in the VCO, R468 is referred to as a center frequency control.

5-15 AUDIO AMPLIFIER/DETECTOR

A block diagram of the audio amplifier/detector unit is shown in Figure 5-20 and the schematic is shown in Figure 5-21. This unit includes a limiter, a narrowband amplifier, two coherent detectors, a peak detector, and a voltage level sensing amplifier.

The limiter consists of two diodes, CR301 and CR302, in shunt and in reverse polarity. The function of the limiter is to prevent overdrive and excessive saturation of the amplifier and coherent detectors.

The first amplifier stage, Q301, has provision for adjusting its gain by means of two front panel controls, REFERENCE COARSE and REFERENCE FINE. The gain is adjusted by varying the current through the diodes CR303 and CR304. These diodes are used as variable resistors shunting the input and output of the amplifier stage.

The next amplifier stage, Q302 and Q303, is a frequency selective stage. The selectivity is determined by the gain in Q302 and the Q of the feedback network. The bandwidth of this amplifier is approximately 150 Hz. The stage is identical to that in the AFC detector unit, Q406 and Q407.

The next stage of amplification and buffering is obtained from Q304 and Q305. Current feedback through R323 ensures the stability of this amplifier. The output of the emitter follower drives the coherent detector which provides an output for Reference Normal. The dynamic range of the amplifier and coherent detector has been designed such that no limiting occurs at the highest usable signal level. The presence of noise with its associated voltage spikes have also been accounted for. A 3 to 1 sigma criteria has been established. Approximately 98.5 percent of the time a voltage spike would not saturate the amplifier.

The coherent detector obtains its reference signal from the 1-kHz oscillator. The time constant of its output is adjusted by a front panel control ganged to the Reference Coarse adjust.

The signal at the input to the coherent detector is also applied to the Reference Expand channel consisting of amplifier Q306 and emitter follower Q307. The amplification provided by Q306 is a multiplier of the meter scale resolution when the meter is switched from a Normal to Expand Reference position. This multiplying factor is determined by the ratio of resistor values R332 to R333.

A function of the Amplifier Detector unit is to provide an indication that the IF signal is present. Moreover, this must be accomplished at signal levels as low as -115 dBm. Therefore, a coherent detector was chosen as a means for detecting the presence of the audio

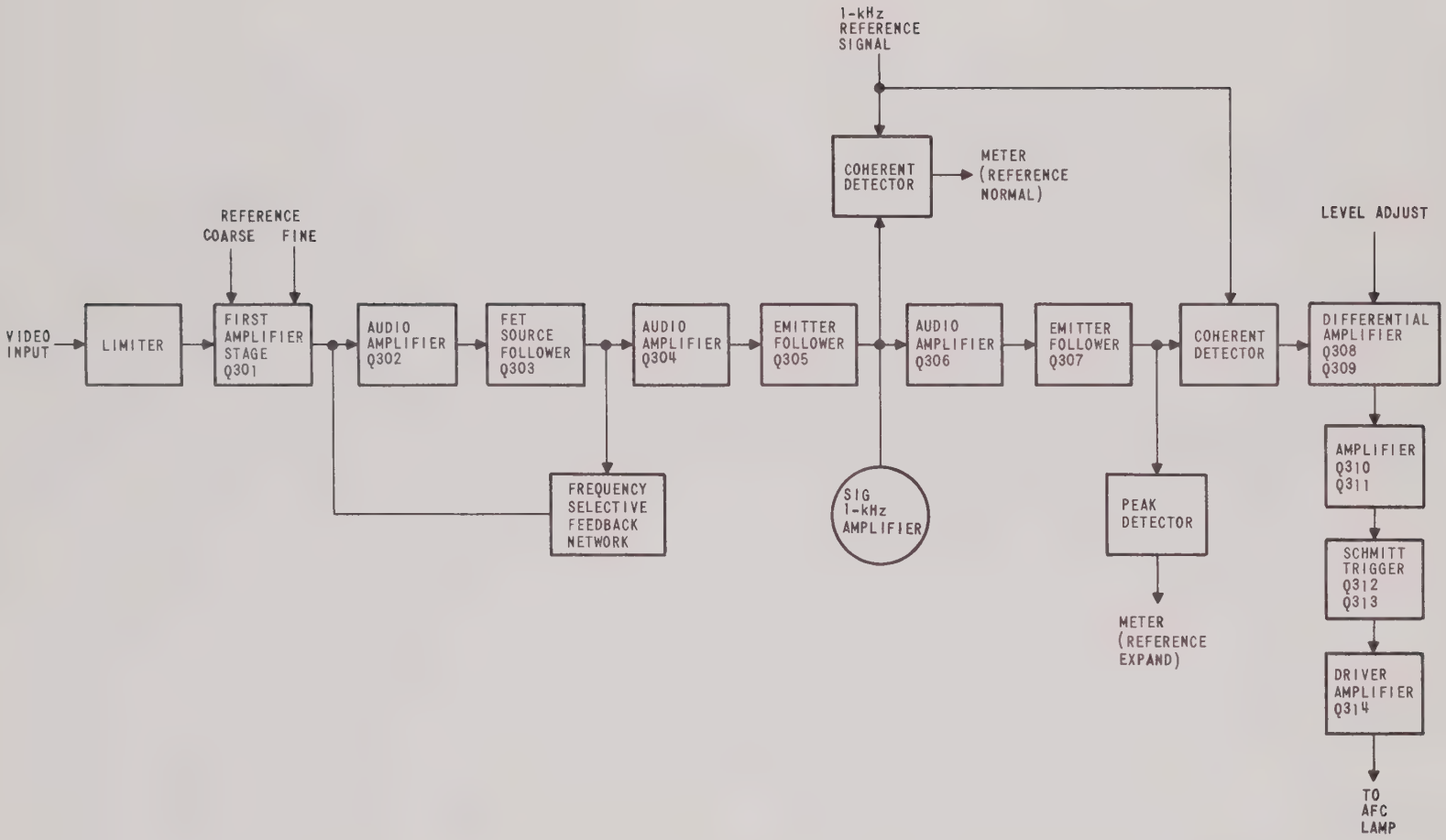


FIGURE 5-20. AUDIO AMPLIFIER DETECTOR BLOCK DIAGRAM

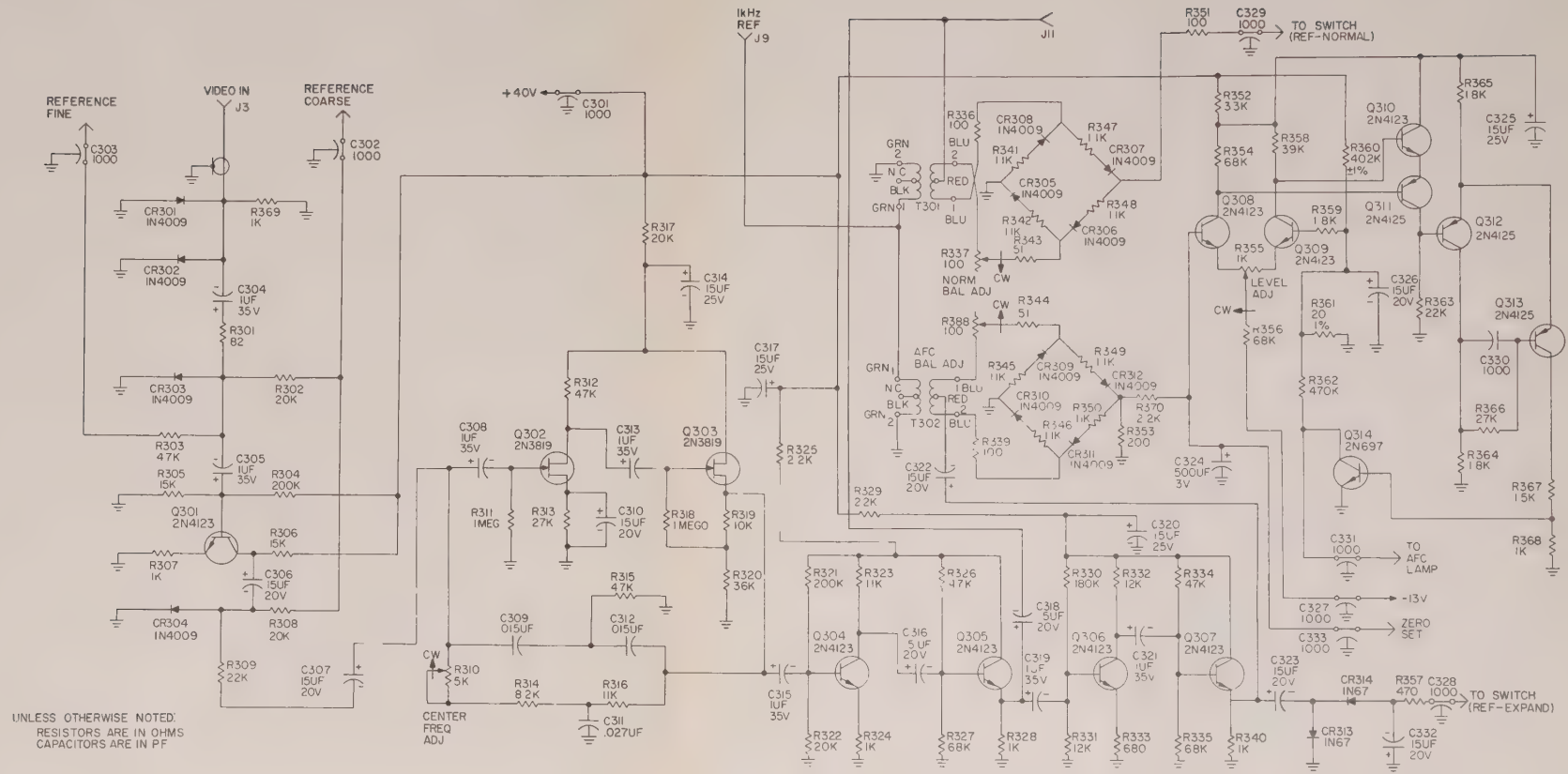


FIGURE 5-21. AUDIO AMPLIFIER DETECTOR SCHEMATIC

FIGURE 5-21

signal. The output of the coherent detector is applied to the input of a voltage level indicator. The indicator includes a differential amplifier Q308 and Q309. A reference voltage level is also applied to the differential amplifier. This reference is derived from a -13 volt line and can be adjusted by varying resistor R356. This adjustment is performed in the factory and is set so that a signal level sufficient to give approximate sense a 1/6 indication in Reference Normal position causes the AFC light to illuminate. The output of the differential amplifier is amplified and then applied to the Schmitt trigger, Q312 and Q313. The Schmitt trigger will cause the light driver amplifier, Q314, to conduct. The AFC lamp and current limiting resistor, R912, are a collector load for this stage. Resistor R362 is a feedback resistor which enables a reduction in the hysteresis of the switching characteristic.

5-16 1-kHz OSCILLATOR

A block diagram of the 1-kHz oscillator is shown in Figure 5-22 and a schematic is shown in Figure 5-23. This unit includes a 1-kHz oscillator, a squaring circuit, four emitter follower driver stages, and a relay switching circuit.

The basic oscillator consists of Q601 and Q602 amplifier and emitter follower stages and a feedback circuit consisting of C607, R608, C608, C605, R602, and a group of resistors R611, R612, R615, R616, and R617. Adjustment of R616 enables the oscillator frequency to be varied. R615 and R616 are thermistors which compensate for temperature changes in the component values of the feedback circuit. Consequently the frequency stability of the oscillator is quite good even at 120^{O}F. At 100^{O}F the oscillator frequency varies approximately 5 Hz from that at room temperature. Since the audio amplifiers in the rest of the system have approximately a 150-Hz bandwidth, a 5-Hz variation will not degrade the system. Resistor R604 is a feedback resistor which ensures stable amplifier gain of Q601. The output of the oscillator is applied to an emitter follower, Q603 which serves as a buffer stage. To provide further isolation and to enable sufficient drive signal for the coherent detector an emitter follower, Q604, is included. Similarly, an emitter follower, Q605 is included as the driver for the second coherent detector.

Referring to Figure 5-22, the sinusoidal signal output from Q605 is amplified and shaped into a square wave. Resistor R624 is used for adjusting the symmetry of the square wave for equal on and off time.

The square wave is fed to two emitter followers which provide an output for modulating the noise generator and IF preamplifier. Resistor R635 is an adjustment to ensure the same positive drive signal to the noise generator for the energized and unenergized states of the relay.

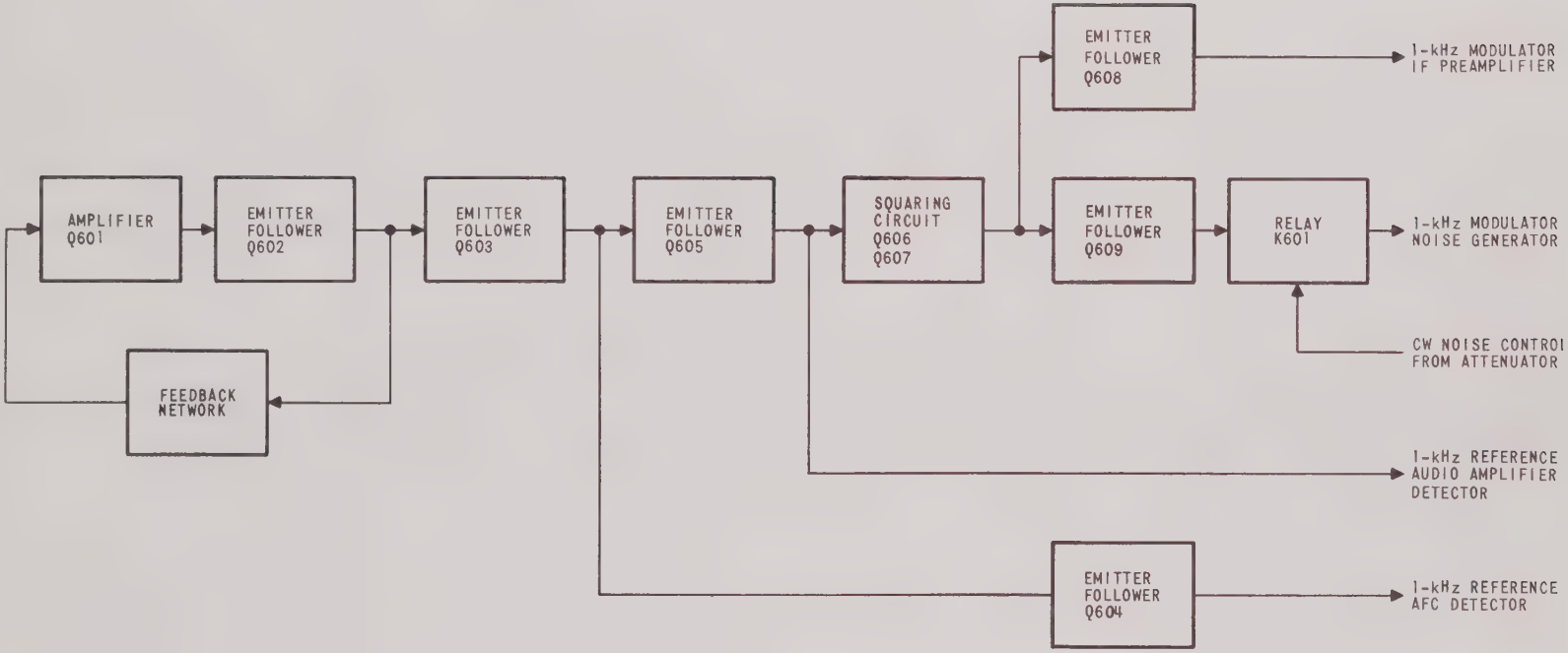


FIGURE 5-22. 1-kHz OSCILLATOR BLOCK DIAGRAM

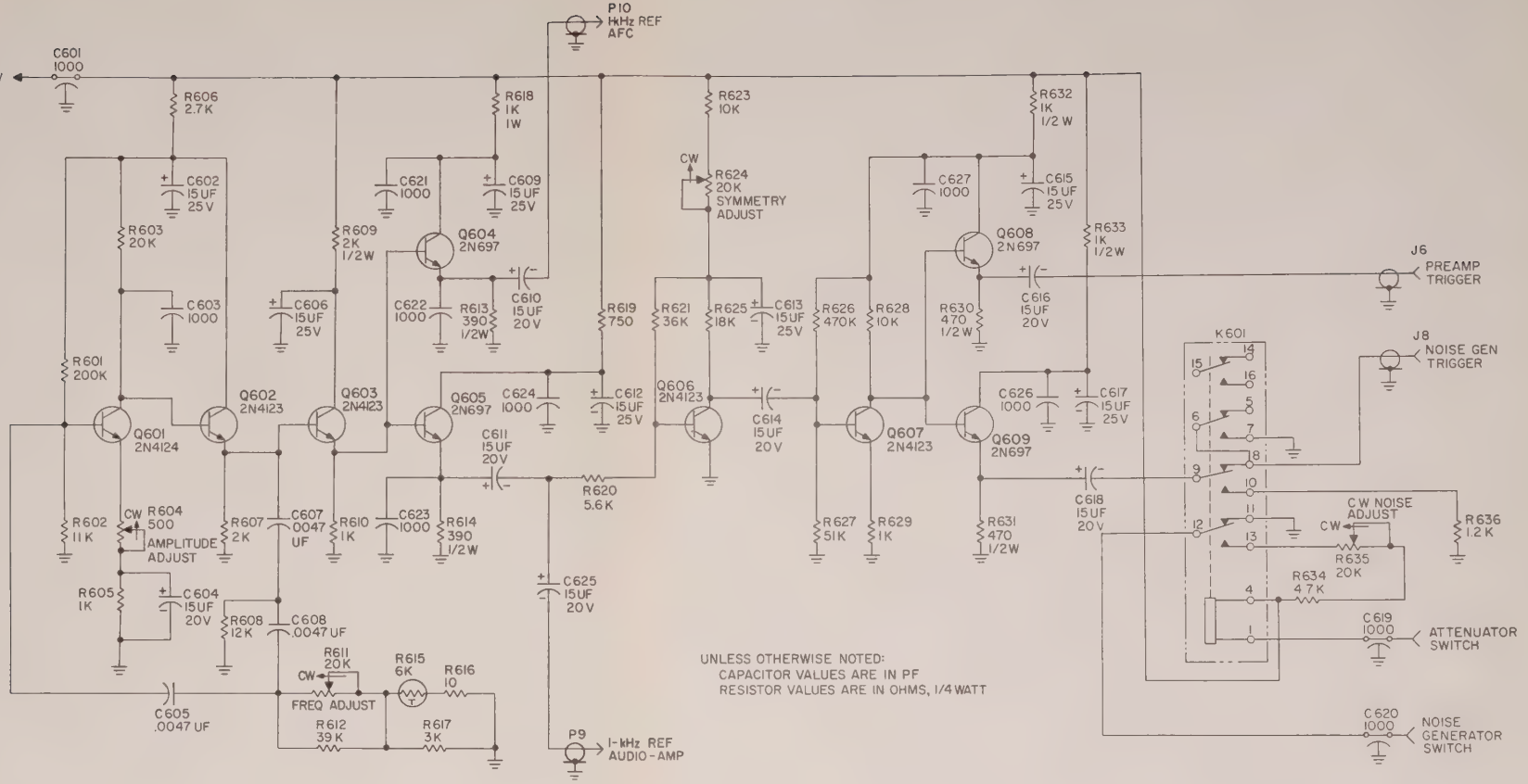


FIGURE 5-23. 1-kHz OSCILLATOR SCHEMATIC

5-17 POWER SUPPLY

The RF Attenuation Calibrator is supplied with a modular power supply. The general specification is:

1. DC output voltage V $\pm$1V
2. Maximum output current 600 mA
3. Regulation, load and line, 0.01 percent maximum
4. Short circuit protection provided

A schematic for the power supply is given in Figure 5-24.

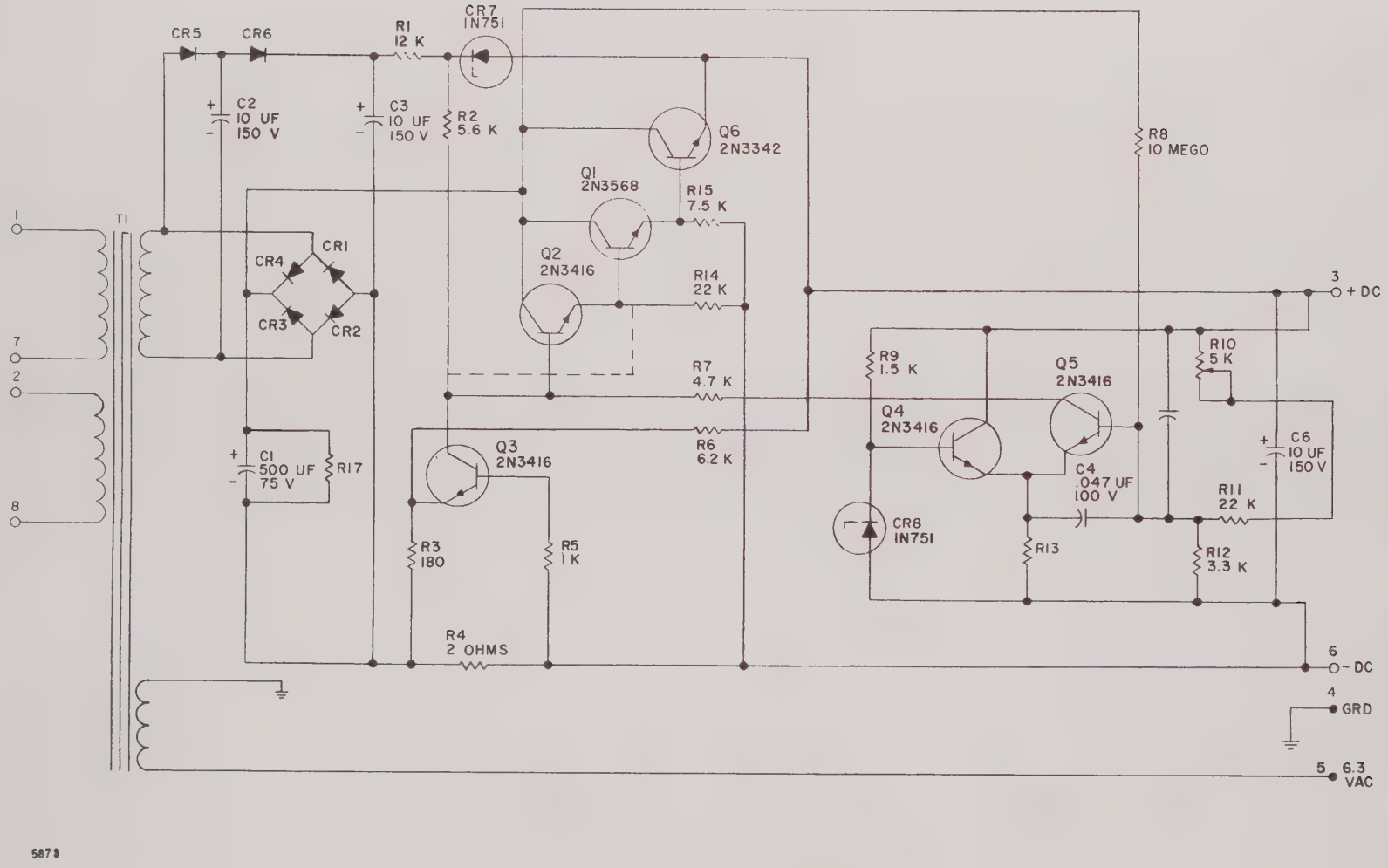


FIGURE 5-24. POWER SUPPLY SCHEMATIC

SECTION VI

LIST OF REPLACEABLE PARTS

PRECISION ATTENUATOR CALIBRATOR (P/N 13710)

Reference Symbol	Description	Manufacturer	Part Number
C901, 11	Capacitor, electrolytic, 15 μF, 25V	Sprague	TE7205
C903, 4	Capacitor, electrolytic, 15 μF, 20V		CS13BE156M
C905	Capacitor, electrolytic, 100 μF, 25V	Sprague	TE1211
C906	Capacitor, electrolytic, 2000 μF, 3V	Sprague	TL1071
C907, 14, 15, 8, 10	Capacitor, paper, 0.01 μF, 600V		CK63AW103M
C912	Capacitor, electrolytic, 500 μF, 3V	Sprague	TE1068
CR901, 2, 3, 5	Diode		1N67-
CR904	Diode		1N965B
DS901	Lamp, 6V	Chicago Miniature Lamp	CM381
DS902, 903	Lamp, 6V	Chicago Miniature Lamp	44
DS906	AFC light	Chicago Miniature Lamp	CM385
F901, 902	Fuse, Slo Blo, 0.5A (115V), 0.25A (230V)		FO2B250V1/2AS
J14	Connector	Gremar	10858
L901, 2	Inductor	AIL	212612
M901	Meter	AIL	211979
	Precision attenuator	AIL	211808
P5	Connector, TNC	Dage	8000-1
PS901	Power Supply	AIL	211965
R901	Resistor, fixed, 18 k, 1/4 W		RC07GF183J
R903	Resistor, fixed, 20 k, 1/4 W		RC07GF203J
R904	Resistor, fixed, 1 k, 1/4 W		RC07GF102J

PRECISION ATTENUATOR CALIBRATOR (P/N 13710) (cont)

Reference Symbol	Description	Manufacturer	Part Number
R905	Resistor, fixed, 8.2 k, 1/4 W		RC07GF822J
R906	Resistor, variable, 1 k	AIL	212106-1
R907	Resistor, fixed, 200 k, 11 W	Memcor	MAL-11
R908, 914	Resistor, variable, dual	AIL	115289-15
R909	Resistor, fixed, 3.9 k, 1/4 W		RC07GF392J
R911	Resistor, fixed, 39 k, 1/2 W		RC20GF393J
R912	Resistor, fixed, 510 k, 2 W		RC42GF511J
R913	Resistor, variable, 50 k	AIL	212106-2
R915	Resistor, fixed, 10 k, 1/4 W		RC07GF103J
R917	Resistor, fixed, 3 k, 1/4 W		RC07GF302J
R918	Resistor, fixed, 100 k, 1/4 W		RC07GF101J
R919	Resistor, fixed, 4.7 k, 1/4 W		RC07GF472J
R920	Resistor, fixed, 300 k, 1/4 W		RC07GF304J
R921	Resistor, fixed, 1.5 k, 1/4 W		RC07GF152J
R922	Resistor, fixed, 1 k, 1/4 W		RC07GF102J
S901	Switch, push type	AIL	211823
S902	Switch, push type	AIL	211824
S904, 905	Switch, pushbutton	Switchcraft	961

POSTAMPLIFIER (P/N 211735)

C1	Capacitor, glass, 27 pF	Corning	TY06-271J
C2	Capacitor, variable, 10 to 75 pF	Erie	557-091-N1500-10-15 pF
C3	Capacitor, ceramic, 330 pF		CK05CW331K
C4, 5, 6, 9, 13, 14, 17-21, 25, 26, 30, 33-39			CK05CW102K
C7	Capacitor, ceramic, 270 pF		CK05CW271K
C8, 29	Capacitor, ceramic, 680 pF		CK05CW681K
C11, 12, 15, 16, 40	Capacitor, ceramic, 100 pF		CK05CW101K
C22	Capacitor, ceramic, 240 pF	Erie	8141
C23	Capacitor, ceramic, 470 pF	Erie	8161

POSTAMPLIFIER (P/N 211735) (cont)

Reference Symbol	Description	Manufacturer	Part Number
C24, 27	Capacitor, ceramic, 150 pF		CK05CW151K
C28	Capacitor, ceramic, 150 pF	Erie	8141
C31, 32	Capacitor, electrolytic, 15 μF, 25V	Sprague	TE1205
C41, 42, 43	Capacitor, feedthru, 1000 pF	Allen-Bradley	F132B
CR1, 2	Diode, pin	Hewlett-Packard	HPA-3039
CR3	Diode		1N87A
CR4, 5	Diode		1N4009
J1	Connector, TNC	Dage	8016-1
L1, 3, 10	Inductor, variable	AIL	118244-11
L2, 5, 7, 8, 9, 13, 14, 15, 16	Inductor, molded, 1.1 μH	Speers Carbott	10101-1
L4, 6, 12	Inductor, variable	AIL	118244-1
L11	Inductor, molded, 3 μH	Speers Carbon	10100-2
P2	Connector, TNC	Dage	8001-1
P3, 4	Connector, BNC		UG88E/U
Q1, 2, 3, 4	Transistor		2N2996
Q5	Transistor		2N1141
Q6, 7	Transistor		2N706
R1	Resistor, fixed, 2.7 k, 1/4 W		RC07GF272J
R2	Resistor, fixed, 1.5 k, 1/4 W		RC07GF152J
R3, 5, 6, 9, 10, 13, 14	Resistor, fixed, 2 k, 1/4 W		RC07GF202J
R4	Resistor, fixed, 620 ohms, 1/4 W		RC07GF621J
R7, 11, 15	Resistor, fixed, 680 ohms, 1/4 W		RC06GF681J
R8, 12, 16	Resistor, fixed, 820 ohms, 1/4 W		RC07GF821J
R17, 18	Resistor, fixed, 1 k, 1/4 W		RC07GF102J
R19	Resistor, fixed, 560 ohms, 1/4 W		RC07GF561J
R20	Resistor, fixed, 1.3 k, 1/4 W		RC07GF132J
R21, 25, 26	Resistor, fixed, 5.6 k, 1/4 W		RC07GF562J
R22, 28	Resistor, fixed, 1.2 k, 1/4 W		RC07GF122J

POSTAMPLIFIER (P/N 211735) (cont)

Reference Symbol	Description	Manufacturer	Part Number
R23, 27	Resistor, fixed, 3.3 k, 1/4 W		RC07GF332J
R29, 30	Resistor, fixed, 11 ohms, 1/4 W		RC07GF110J
R31	Resistor, fixed, 560 ohms, 1 W		RC32GF561J

IF PREAMPLIFIER (P/N 211770)

C201, 3, 6, 7, 10, 11, 12, 15, 16, 18, 20, 22, 23, 24, 25, 26, 27, 28	Capacitor, ceramic, 1000 pF		CK60AW102M
C202	Capacitor, variable, 10 to 75 pF	Erie	557-091-N1500-10-75 pF
C204, 30	Capacitor, ceramic, 220 pF		CK05CW221K
C205	Capacitor, ceramic, 100 pF		CK05CW101K
C208, 13	Capacitor, ceramic, 100 pF	Erie	8151
C209	Capacitor, ceramic, 10 pF		
C214	Capacitor, electrolytic, 50 μF, 50V	Cornell-Dubilier	BR50-50
C219	Capacitor, ceramic, 75 pF	Erie	8141
C221	Capacitor, ceramic, 180 pF		CK05CW181K
C229	Capacitor, feedthru, 1000 pF	Allen-Bradley	FB2B
CR201, 3, 4	Diode	Hewlett-Packard	HPA-2800
J5	Connector, TNC	Dage	8016-1
L201, 6, 9	Inductor, variable	AIL	118244-1
L203	Inductor, variable	AIL	118244-2
L207, 8, 210-214	Inductor, molded, 3 μH	Speers Carbon	10100-2
P6	Connector, BNC		UG88E/U
P7	Connector, TNC	Date	8000-1
Q201	Transistor	KMC Semi-Con. Corp.	K2523
Q202	Transistor		2N3866
Q204	Transistor		2N2950

IF PREAMPLIFIER (P/N 211770) (cont)

Reference Symbol	Description	Manufacturer	Part Number
R201	Resistor, fixed, 8.2 k, 1/4 W		RC07GF822J
R202	Resistor, fixed, 3.9 k, 1/4 W		RC07GF392J
R203	Resistor, fixed, 75 ohms, 1/4 W		RC07GF750J
R204	Resistor, fixed, 300 ohms, 1/4 W		RC07GF301J
R205, 224, 217	Resistor, fixed, 510 ohms, 1/4 W		RC07GF511J
R206	Resistor, fixed, 6.2 k, 1/4 W		RC07GF622J
R207	Resistor, fixed, 22 k, 1/4 W		RC07GF223J
R208	Resistor, fixed, 47 ohms, 1/4 W		RC07GF470J
R209	Resistor, fixed, 390 ohms, 1 W		RC32GF391J
R210	Resistor, fixed, 20 ohms, 1/4 W		RC07GF200J
R211	Resistor, fixed, 3 k, 1/4 W		RC07GF302J
R212	Resistor, fixed, 910 ohms, 1/4 W		RC07GF911J
R213	Resistor, fixed, 30 ohms, 1/2 W		RC20GF300J
R214	Resistor, fixed, 110 ohms, 1/2 W		RC20GF111J
R19	Resistor, fixed, 270 ohms, 1/4 W		RC07GF271J
R220	Resistor, fixed, 180 ohms, 1/4 W		RC07GF181J
R221, 2, 3	Resistor, fixed, 1 k, 1/2 W		RC20GF102J
R225	Resistor, fixed, 620 ohms, 1/4 W		RC07GF621J

1 kHz AMPLIFIER (P/N 212150)

C301, 2, 3, 27, 28, 29, 31, 33	Capacitor, feedthru, 1000 pF	Allen-Bradley	FB2B
C304, 5, 8, 13, 15, 19, 21	Capacitor, electrolytic, 1 μF, 35V	Sprague	150D105 × 9035A2
C306, 7, 10, 16, 18, 22, 23, 26, 36	Capacitor, electrolytic, 15 μF, 20V		CS13BE156M
C309, 12	Capacitor, mica, 0.015 μF	Westcap	4M153K
C311	Capacitor, mica, 0.027 μF	Westcap	4M273K
C314, 17, 20, 25	Capacitor, electrolytic, 15 μF, 25V	Sprague	TE1205

1 kHz AMPLIFIER (P/N 212150) (cont)

Reference Symbol	Description	Manufacturer	Part Number
C324	Capacitor, electrolytic, 500 μF, 3V	Sprague	30D507G003DF2
C330	Capacitor, ceramic, 100 pF		CK05CW101K
CR301 thru 312	Diode		1N4009
CR313, 14	Diode		1N67
J3	Connector, BNC		UG1094V
J9, 11	Connector, BNC		UG1098A/U
Q301, 4 thru 10	Transistor		2N4123
Q302, 3	Transistor		2N3819
Q311, 12, 13	Transistor		2N4125
Q314	Transistor		2N697
R301	Resistor, fixed, 82 ohms, 1/4 W		RC07GF820J
R302, 8, 17, 22	Resistor, fixed, 20 k, 1/4 W		RC07GF203J
R303	Resistor, fixed, 4.7 k, 1/4 W		RC07GF472J
R304, 321	Resistor, fixed, 200 k, 1/4 W		RC07GF204J
R305, 6	Resistor, fixed, 15 k, 1/4 W		RC07GF153J
R307, 24, 28, 40, 68, 69	Resistor, fixed, 1 k, 1/4 W		RC07GF102J
R309, 63	Resistor, fixed, 22 k, 1/4 W		RC07GF223J
R310	Resistor, variable, 5 k, 1/2 W	Bourns	3307P
R311, 18	Resistor, fixed, 1 m, 1/4 W		RC07GF105J
R312, 26, 34	Resistor, fixed, 47 k, 1/4 W		RC07GF473J
R313, 366	Resistor, fixed, 27 k, 1/4 W		RC07GF273J
R314	Resistor, fixed, 8.2 k, 1/4 W		RC07GF822J
R315	Resistor, fixed, 4.7 k, 1/4 W		RC07GF472J
R316, 323	Resistor, fixed, 11 k, 1/4 W		RC07GF113J
R319	Resistor, fixed, 10 k, 1/4 W		RC07GF103J
R320	Resistor, fixed, 36 k, 1/4 W		RC07GF363J
R325, 29, 70	Resistor, fixed, 2.2 k, 1/4 W		RC07GF222J
R327, 35, 54, 56	Resistor, fixed, 68 k, 1/4 W		RC07GF683J

1 kHz AMPLIFIER (P/N 212150) (cont)

Reference Symbol	Description	Manufacturer	Part Number
R330	Resistor, fixed, 180 k, 1/4 W		RC07GF184J
R331, 2	Resistor, fixed, 12 k, 1/4 W		RC07GF123J
R333	Resistor, fixed, 680 k, 1/4 W		RC07GF681J
R336, 39, 51	Resistor, fixed, 100 k, 1/4 w		RC07GF101J
R337, 8	Resistor, variable, 100 ohms, 1/2 W	Bourns	3300P
R341, 42, 45, 46, 47, 48, 49, 50	Resistor, fixed, 1.1 k, 1/4 W		RC07GF112J
R343, 344	Resistor, fixed, 51 ohms, 1/4 W		RC07GF510J
R352	Resistor, fixed, 3.3 k, 1/4 W		RC07GF332J
R353	Resistor, fixed, 200 k, 1/4 W		RC07GF201J
R355	Resistor, variable, 1 k, 1/2 W		3307P
R357	Resistor, fixed, 470 k, 1/4 W		RC07GF471J
R358	Resistor, fixed, 39 k, 1/4 W		RC07GF393J
R359, 64, 65	Resistor, fixed, 1.8 k, 1/4 W		RC08GF182J
R360	Resistor, fixed, 40.2 k, 1%	1 RC	DCC
R361	Resistor, fixed, 20 ohms, 1%		RC07GF200J
R362	Resistor, fixed, 470 k, 1/4 W		RC07GF474J
R367	Resistor, fixed, 1.5 k, 1/4 W		RC07GF152J
T301, T302	Transformer	Triad	TY28X-T

AUTOMATIC FREQUENCY CONTROL (P/N 212375)

C401, 406-408, 411, 12, 13, 16, 17, 18, 20	Capacitor, ceramic, 1000 pF		CK05CW102M
C409, 414	Capacitor, ceramic, 270 pF		CK05CW271K
C410, 415	Capacitor, ceramic, 390 pF		CK05CW391K
C419	Capacitor, ceramic, 56 pF		CK05CW560K
C421, 30, 39	Capacitor, electrolytic, 15 μF, 25V	Sprague	TE1205
C422	Capacitor, variable, 0.8-10 pF	Johanson	JMC2951
C423	Capacitor, glass, 62 pF (N750)		CK56U620J
C424, 25	Capacitor, ceramic, 680 pF		CK05CW681K

AUTOMATIC FREQUENCY CONTROL (P/N 212375) (cont)

Reference Symbol	Description	Manufacturer	Part Number
C426-429, 431, 33, 40, 41, 42	Capacitor, electrolytic, 15 μF, 20V		CS13BE156M
C432, 37, 38	Capacitor, electrolytic, 1 μF, 35V	Sprague	150D105 x 9035A2
C434, 435	Capacitor, mica, 0.015 μF	Westlap	4M153K
C436	Capacitor, mica, 0.027 μF	Westlap	4M273K
C443	Capacitor, 15 μF	Sprague	4C38
C445	Capacitor, electrolytic, 100 μF, 50V	Sprague	TE1309
C446, 47	Capacitor, feedthru	Allen-Bradley	FB2B
CR403-408	Diode		1N100
CR409, 10	Diode		1N87A
CR411-414	Diode		1N4009
J4, 10, 15, 16	Connector, BNC		VG 1094/U
L4, 6, 8, 10	Inductor, molded, 3 μH	Speers Carbon	10100-2
L403, 405	Inductor, variable	AIL	118244-11
L407	Inductor, variable	AIL	118244-1
L409	Inductor, variable	AIL	212148
Q401, 402	Transistor		2N2996
Q403	Transistor		2N1141
Q404, 6, 7, 10	Transistor		2N3819
Q405, 8, 9	Transistor		2N4123
R21, 22, 34, 51, 54	Resistor, fixed, 1 k, 1/4 W		RC07GF102J
R23, 69	Resistor, fixed, 10 k, 1/4 W		RC07GF100J
R411, 17, 29, 30, 45, 67	Resistor, fixed 10 k, 1/4 W		RC07GF103J
R453	Resistor, fixed, 68 k, 1/4 W		RC07GF683J
R414, 19	Resistor, fixed, 2.7 k, 1/4 W		RC07GF272J
R410, 15, 20, 58	Resistor, fixed, 51 k, 1/4 W		RC07GF510J
R412, 16	Resistor, fixed, 6.2 k, 1/4 W		RC07GF622J

AUTOMATIC FREQUENCY CONTROL (P/N 212375) (cont)

Reference Symbol	Description	Manufacturer	Part Number
R413, 18	Resistor, fixed, 20 k, 1/4 W		RC07GF200J
R424	Resistor, fixed, 560 k, 1/4 W		RC07GF561J
R425	Resistor, fixed, 470 k, 2 W		RC42GF471J
R426, 27	Resistor, fixed, 51 k, 1/4 W		RC07GF513J
R428	Resistor, fixed, 120 k, 1/4 W		RC07GF124J
R431, 48	Resistor, fixed, 200 k, 1/4 W		RC07GF204J
R432, 33	Resistor, fixed, 15 k, 1/4 W		RC07GF153J
R435	Resistor, fixed, 22 k, 1/4 W		RC07GF223J
R436	Resistor, variable 10 k, 1/2 W		3307P
R437, 44	Resistor, fixed, 1 m, 1/4 W		RC07GF105J
R438, 52	Resistor, fixed, 47 k, 1/4 W		RC07GF473J
R439	Resistor, fixed, 27 k, 1/4 W		RC07GF273J
R440	Resistor, variable, 5 k, 1/2 W	Bourns	3307P
R441	Resistor, fixed, 8.2 k, 1/4 W		RC07GF822J
R442	Resistor, fixed, 4.7 k, 1/4 W		RC07GF472J
R443, 450	Resistor, fixed, 11 k, 1/4 W		RC07GF113J
R446	Resistor, fixed, 36 k, 1/4 W		RC07GF363J
R447, 49, 63	Resistor, fixed, 20 k, 1/4 W		RC07GF203J
R455	Resistor, fixed, 2 k, 1/2 W		RC20GF202J
R456	Resistor, fixed, 100 k, 1/4 W		RC07GF101J
R457	Resistor, variable, 100 k, 1/2 W	Bourns	3300P
R459, 60, 61, 62	Resistor, fixed, 1.1 k, 1/4 W		RC07GF112J
R464, 65	Resistor, fixed, 100 k, 1/4 W		RC07GF104J
R466	Resistor, fixed, 2.2 k, 1/4 W		RC07GF222J
R468	Resistor, variable, 10 k, 1/2 W	IRC	RV6LAYSA103A
T401	Transformer	Triad	TY28X-T

FILTER ASSEMBLY (P/N 211981)

C801-C805	Capacitor, feedthru, 1000 pF	Allen-Bradley	FB2B
C806-C815	Capacitor, stand-off, 1000 pF	Allen-Bradley	SB4A

FILTER ASSEMBLY (P/N 211981) (cont)

Reference Symbol	Description	Manufacturer	Part Number
L801-L809	Inductor, molded, 1.1 μH	Speers Carbon	10101-1
R803	Resistor, fixed, 4.87 k, ±1%		RN60C4871F
	Connector	Deutsch	754-7-OSN

1 kHz OSCILLATOR (P/N 212140)

C601, 619, 620	Capacitor, feedthru, 1000 pF	Allen-Bradley	FB2B
C602, 606, 609, 612, 613, 615, 617	Capacitor, electrolytic, 15 μF, 25V	Sprague	TE7205
C603, 621, 622, 623, 624, 626, 627	Capacitor, ceramic, 1000 pF		CK05CW102K
C604, 610, 611, 614, 616, 618, 625	Capacitor, electrolytic, 15 μF, 20V		CS13BE156M
C605, 607, 608	Capacitor, mica, 0.0047 μF	Westcap	4M472K
C628	Capacitor, electrolytic, 0.5 μF, 200V	Aerovox	P8292ZN12
CR501, 507	Diode		1N100A
CR503-505	Diode	Hewlett-Packard	HPA2800
CR506	Diode, zener, 15V		1N965-B
J6	Connector, BNC, right angle		UG1174/U
J8	Connector, BNC		UG1094/U
K601	Relay	Phillips Advance	67DP-K-4C5
L501, 504, 507	Inductor, variable	AIL	118244-2
L502, 503, 505, 506, 508, 511-518	Inductor, molded, 3.0 μH	Speers Carbon	10100-2
P9, P10	Connector, BNC		UG88E/U

1 kHz OSCILLATOR (P/N 212140) (cont)

Reference Symbol	Description	Manufacturer	Part Number
Q501, 502, 503	Transistor		2N1742
Q601	Transistor		2N4124
Q602, 603, 606, 607	Transistor		2N4123
Q604, 605, 608, 609	Transistor		2N697
R522, 523	Resistor, fixed, 10 ohms, 1/4 W		RC07GF100J
R601	Resistor, fixed, 200 k, 1/4 W		RC07GF204J
R602	Resistor, fixed, 11 k, 1/4 W		RC07GF113J
R603	Resistor, fixed, 20 k, 1/4 W		RC07GF203J
R604	Resistor, variable, 500 ohms, 1/2 W	Bourns	3300P
R605, 610, 629	Resistor, fixed, 1 k, 1/4 W		RC07GF102J
R606	Resistor, fixed, 2.7 k, 1/4 W		RC07GF272J
R607	Resistor, fixed, 2 k, 1/4 W		RC07GF202J
R608	Resistor, fixed, 12 k, 1/4 W		RC07GF123J
R609	Resistor, fixed, 2 k, 1/2 W		RC20GF202J
R611, 635	Resistor, variable, 20 k, 1/2 W	Bourns	3307P
R612	Resistor, fixed, 39 k, 1/4 W		RC07GF393J
R613, 614	Resistor, fixed, 390 ohms, 1/2 W		RC20GF391J
R615	Thermistor, 6 k, $\pm$10%	Fenwal	JA36J1
R616	Resistor, fixed, 10 ohms, 1/4 W		RC07GF100J
R617	Resistor, fixed, 3 k, 1/4 W		RC07GF302J
R618	Resistor, fixed, 1 k, 1 W		RC32GF102J
R619	Resistor, fixed, 750 ohms, 1 W		RC32GF751J
R620	Resistor, fixed, 5.6 k, 1/4 W		RC07GF562J
R621	Resistor, fixed, 36 k, 1/4 W		RC07GF363J
R624	Resistor, variable, 50 k, 1/4 W	Bourns	3301P
R625	Resistor, fixed, 18 k, 1/4 W		RC07GF183J
R626	Resistor, fixed, 470 k, 1/4 W		RC07GF474J
R627	Resistor, fixed, 51 k, 1/4 W		RC07GF513J
R628, 623	Resistor, fixed, 10 k, 1/4 W		RC07GF103J

1 kHz OSCILLATOR (P/N 212140) (cont)

Reference Symbol	Description	Manufacturer	Part Number
R630, 631	Resistor, fixed, 470 ohms, 1/2 W		RC20GF471J
R632, 633	Resistor, fixed, 1 k, 1/2 W		RC20GF102J
R634	Resistor, fixed, 4.7 k, 1/4 W		RC07GF472J
R636	Resistor, fixed, 1.2 k, 1/4 W		RC07GF122J

NOISE GENERATOR (P/N 212030)

C501, 521, 526, 532	Capacitor, feedthru, 1000 pF	Allen-Bradley	FB2B
C502, 503, 504, 507, 510, 511, 513, 514, 515, 518, 520, 522, 523, 524, 525, 527, 528, 530, 531	Capacitor, fixed, 1000 pF		CK60AW102M
C505, 509	Capacitor, ceramic, 62 pF (NPO)	Erie	Style 4845
C506, 512	Capacitor, ceramic, 100 pF		CK05CW101K
C508, 519	Capacitor, electrolytic, 100 μF, 25V	Sprague	TE-1211
C516	Capacitor, ceramic, 56 pF		CK05CW560K
C529	Capacitor, ceramic, 15 μF, 25V	Sprague	TE-7205
J13	Connector, BNC		UG1094/U
P1	Connector, TNC	Dage	8000-1
P8	Connector, BNC		UG88E/U
R501, 514	Resistor, fixed, 51 ohms, 1/4 W		RC07GF510J
R502, 506, 510	Resistor, fixed, 15 k, 1/4 W		RC07GF153J
R503, 507, 511	Resistor, fixed, 3.9 k, 1/4 W		RC07GF392J
R504, 508, 512, 517, 518	Resistor, fixed, 1 k, 1/4 W		RC07GF102J
R505, 509, 513	Resistor, fixed, 560 ohms, 1/4 W		RC07GF561J
R515	Resistor, fixed, 1.1 k, 2 W		RC42GF112J

NOISE GENERATOR (P/N 212030) (cont)

Reference Symbol	Description	Manufacturer	Part Number
R516	Resistor, variable, 100 ohms, 1/2 W	Bourns	3300P-1-101
R519	Resistor, fixed, 150 ohms, 1/4 W		RC07GF151J
R520	Resistor, fixed, 130 ohms, 1/4 W		RC07GF131J
R521	Resistor, fixed, 2 k, 1/4 W		RC07GF202J

PREAMPLIFIER CONVERTER (P/N 013730)

C701-713, 715-718, 720	Capacitor, ceramic, 680 pF		CK05CW681K
C711, 714	Capacitor, ceramic, 10 pF		CK05CW100K
C721	Capacitor, ceramic, 10 pF (NPO)	Erie	831-000-P3K-100J
C722, 723, 725, 726, 728, 729	Capacitor, ceramic, 680 pF		CK05CW681K
C724	Capacitor, ceramic, 10 pF		CK05CW100K
C727	Capacitor, ceramic, 15 pF		CK05CW150K
C730-733	Capacitor, feedthru, 1000 pF	Allen-Bradley	FB2B
CR701	Diode		1N87
CR702-705	Diode, quad	Texas Instruments	A1047-4
CR706	Diode		1N5145
CR707	Diode		1N965B
L701	Inductor, variable	AIL	212588
L702, 703, 704, 706, 707, 708, 712, 715, 717	Inductor, molded, 1.1 μH	Speers Carbon	10101-1
L705, 710, 714, 716, 718	Inductor, ferrite	AIL	212467
L713, 711	Inductor, variable	AIL	118244-1
L719, 721, 722	Inductor, fixed, 1.1 μH	Speers Carbon	10101-1
L720	Inductor, fixed	AIL	212561

PREAMPLIFIER CONVERTER (P/N 013730) (cont)

Reference Symbol	Description	Manufacturer	Part Number
P12	Connector, plug	Deutsch	757-7-OPN-059
P14	Connector, TNC	Dage	8000-1
Q701, 702	Transistor		K-3502
Q703	Transistor		2N1742
R701, 708	Resistor, fixed, 2 k, 1/4 W		RC07GF202J
R702, 709	Resistor, fixed, 1 k, 1/4 W		RC07GF102J
R703	Resistor, fixed, 15 ohms, 1/4 W		RC07GF150J
R704	Resistor, fixed, 240 ohms, 1/4 W		RC07GF241J
R705, 713	Resistor, fixed, 51 ohms, 1/4 W		RC07GF510J
R706, 707	Resistor, fixed, 100 ohms, 1/4 W		RC07GF101J
R710	Resistor, fixed, 22 ohms, 1/4 W		RC07GF220J
R712	Resistor, fixed, 10 k, 1/4 W		RC07GF103J
R714	Resistor, fixed, 220 ohms, 1/4 W		RC07GF221J
R714	Resistor, fixed, 680 ohms, 1/4 W		RC07GF681J
R715	Resistor, fixed, 2.2 k, 1/4 W		RC07GF222J
R716	Resistor, fixed, 8.2 k, 1/4 W		RC07GF822J
R717, 718, 719	Resistor, fixed, 51 ohms, 1/4 W		RC07GF510J
R720	Resistor, fixed, 100 k, 1/4 W		RC07GF104J
R721	Resistor, fixed, 400 ohms, 3 W	Sprague	242E4015
T701, 702	Transformer	AIL	212372
T703, 704	Transformer	AIL	212552

SECTION VII

MAINTENANCE INSTRUCTIONS

7-1 GENERAL

The use of solid-state components for all active elements and the selection of high-quality components throughout assures a long, trouble-free life for the Type 137 RF Attenuation Calibrator. The entire unit is guaranteed against defects in materials and workmanship, as stated in the warranty located inside the front cover of this handbook. Routine maintenance will generally be limited to lubrication of the precision attenuator as described in Section 7-23.

When trouble occurs within the RF Attenuation Calibrator, isolate it to a specific module or component by using the suggestions in paragraph 7-2. The existence of trouble in a module may be determined by examining the waveshapes and voltage levels at the output connectors and comparing them with the information supplied in this handbook. A defective component within a module may be located by utilizing the DC voltage tables of Section VIII.

The wiring of all panel controls and indicators and the interconnecting wiring between subassemblies is shown in Figure 5-8. Figures 7-1 and 7-2 show the location of the various subassemblies in the main chassis.

To remove the unit from its cabinet, remove the four mounting screws located on the front panel and the four screws located on the underside of the cabinet, and slide the entire chassis out of the cabinet.

7-2 TROUBLE ANALYSIS OF RF ATTENUATION CALIBRATOR

The following symptoms and suggested troubleshotting procedures are provided to facilitate the correction of a malfunction.

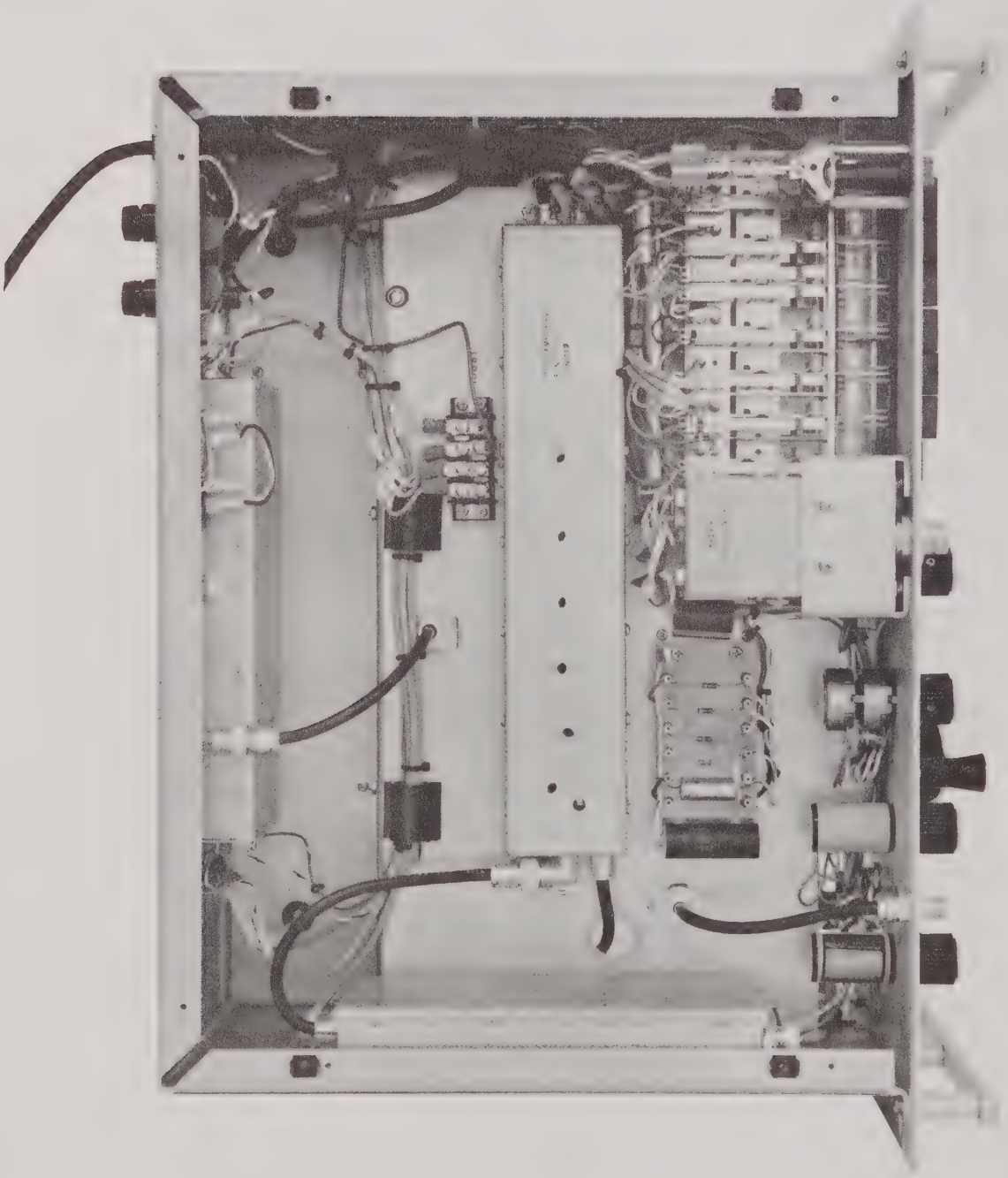


FIGURE 7-1. BOTTOM VIEW OF TYPE 13710 RF ATTENUATION CALIBRATOR

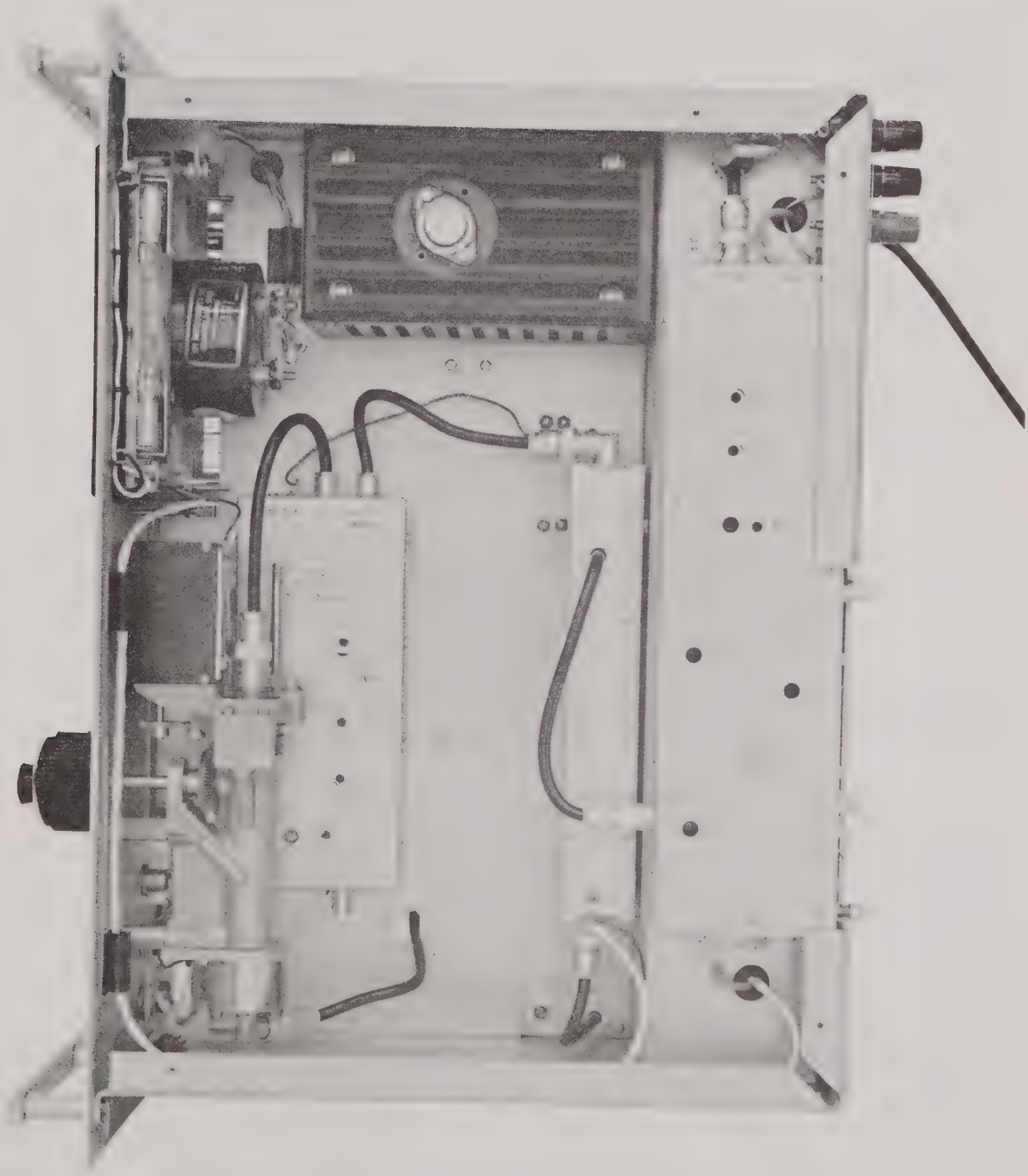
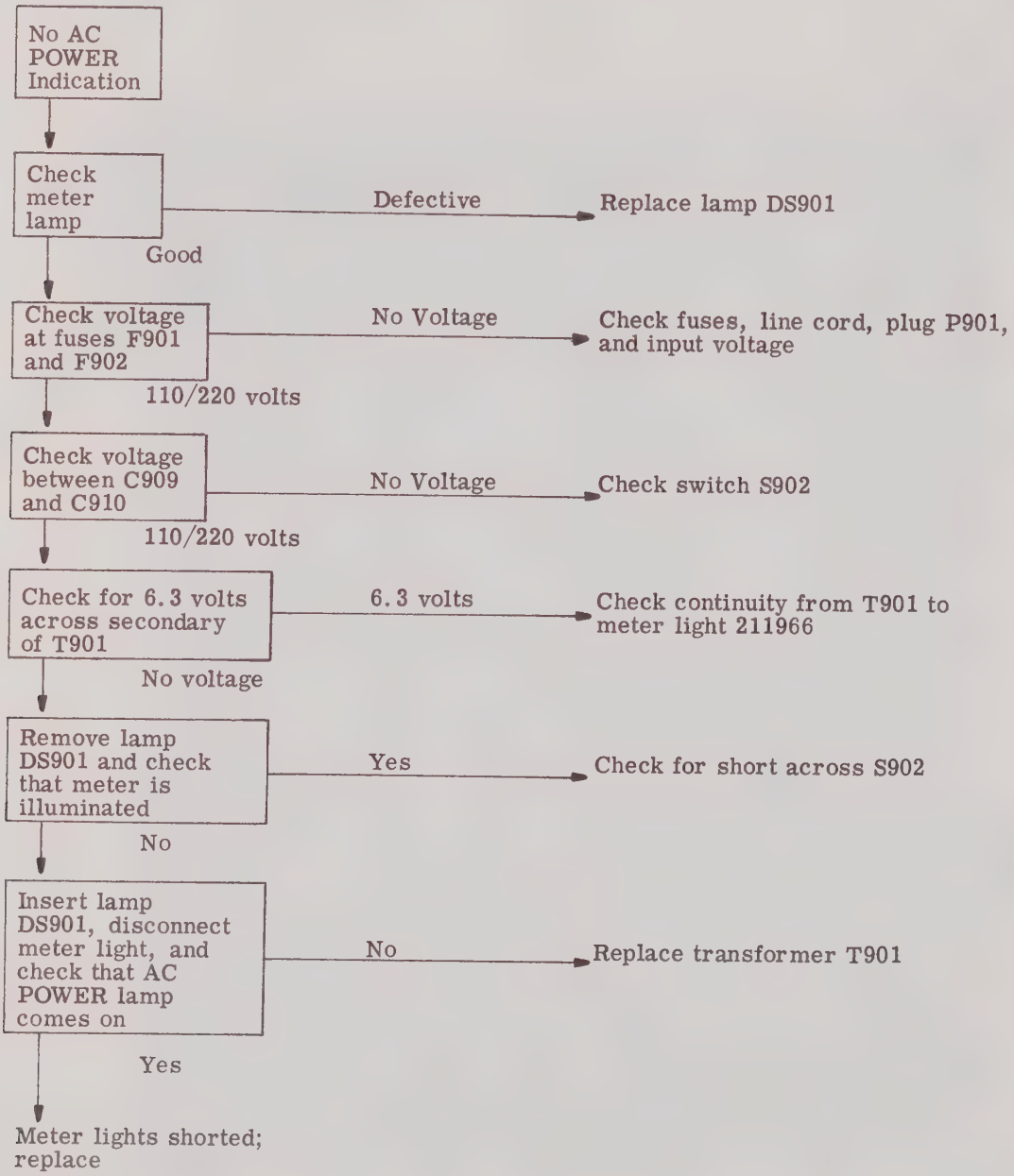
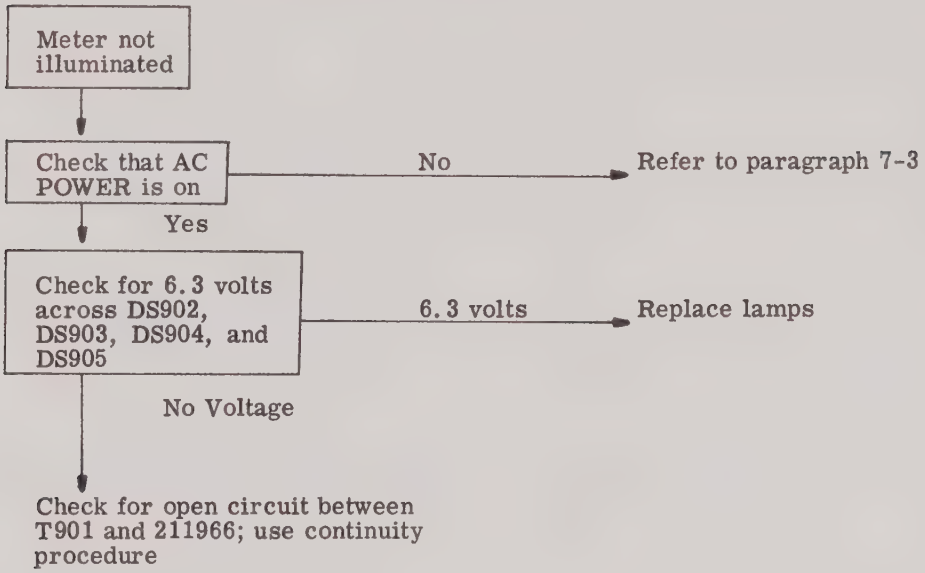


FIGURE 7-2. TOP VIEW OF TYPE 13710 RF ATTENUATION CALIBRATOR

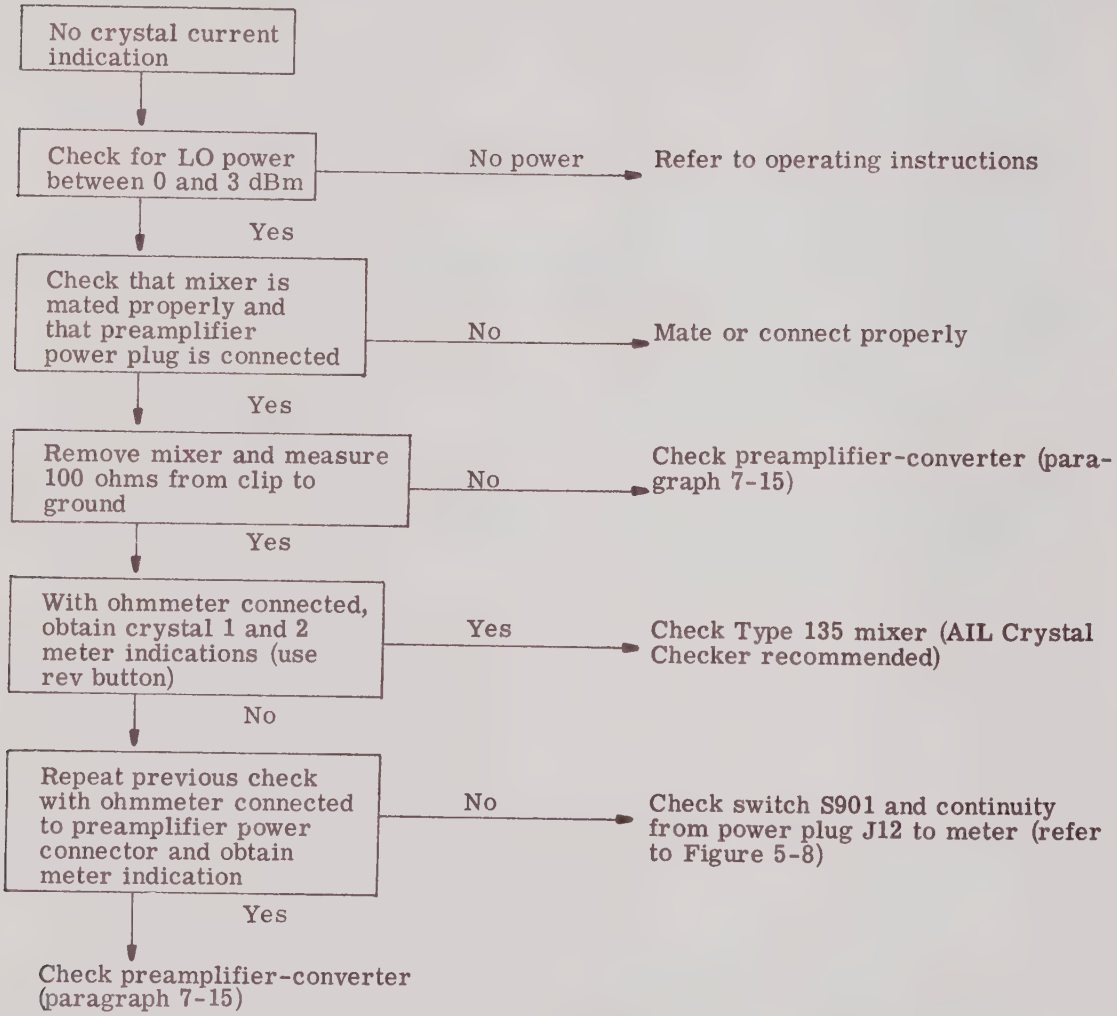
7-3 AC POWER Indicator Does Not Light (Refer to Figure 5-8)


No AC POWER Indication
Check meter lamp
Defective
Replace lamp DS901
Good
Check voltage at fuses F901 and F902
No Voltage
Check fuses, line cord, plug P901, and input voltage
110/220 volts
Check voltage between C909 and C910
No Voltage
Check switch S902
110/220 volts
Check for 6.3 volts across secondary of T901
6.3 volts
Check continuity from T901 to meter light 211966
No voltage
Remove lamp DS901 and check that meter is illuminated
Yes
Check for short across S902
No
Insert lamp DS901, disconnect meter light, and check that AC POWER lamp comes on
No
Replace transformer T901
Yes
Meter lights shorted; replace

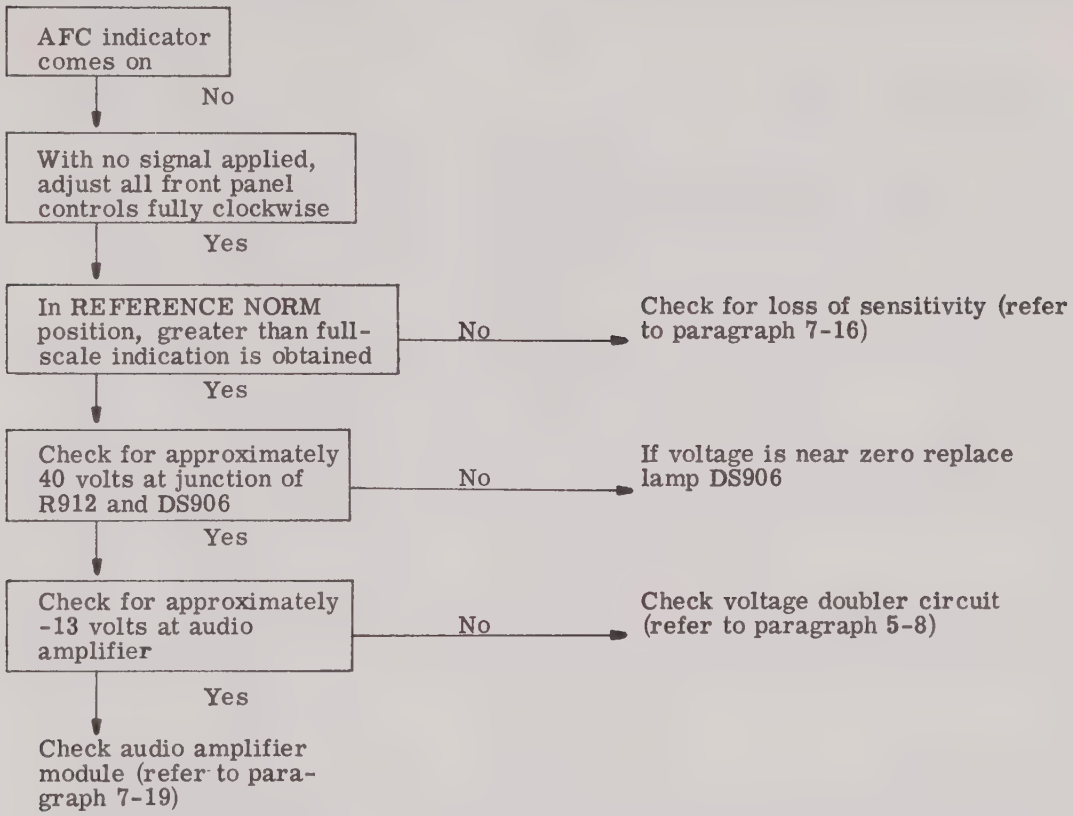
7-4 Meter is Not Illuminated (Refer to Figure 5-8)


Meter not illuminated
Check that AC POWER is on
No
Refer to paragraph 7-3
Yes
Check for 6.3 volts across DS902, DS903, DS904, and DS905
6.3 volts
Replace lamps
No Voltage
Check for open circuit between T901 and 211966; use continuity procedure

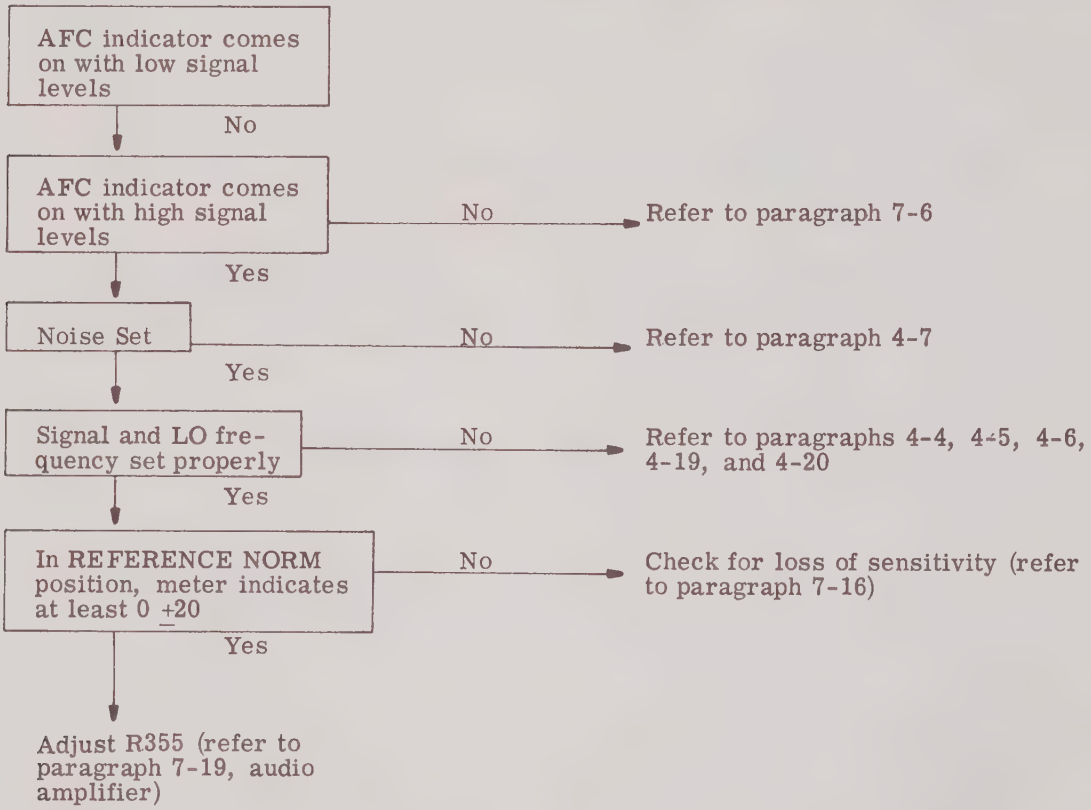
7-5 No Crystal Current Indication


No crystal current indication
Check for LO power between 0 and 3 dBm
No power
Refer to operating instructions
Yes
Check that mixer is mated properly and that preamplifier power plug is connected
No
Mate or connect properly
Yes
Remove mixer and measure 100 ohms from clip to ground
No
Check preamplifier-converter (paragraph 7-15)
Yes
With ohmmeter connected, obtain crystal 1 and 2 meter indications (use rev button)
Yes
Check Type 135 mixer (AIL Crystal Checker recommended)
No
Repeat previous check with ohmmeter connected to preamplifier power connector and obtain meter indication
No
Check switch S901 and continuity from power plug J12 to meter (refer to Figure 5-8)
Yes
Check preamplifier-converter (paragraph 7-15)

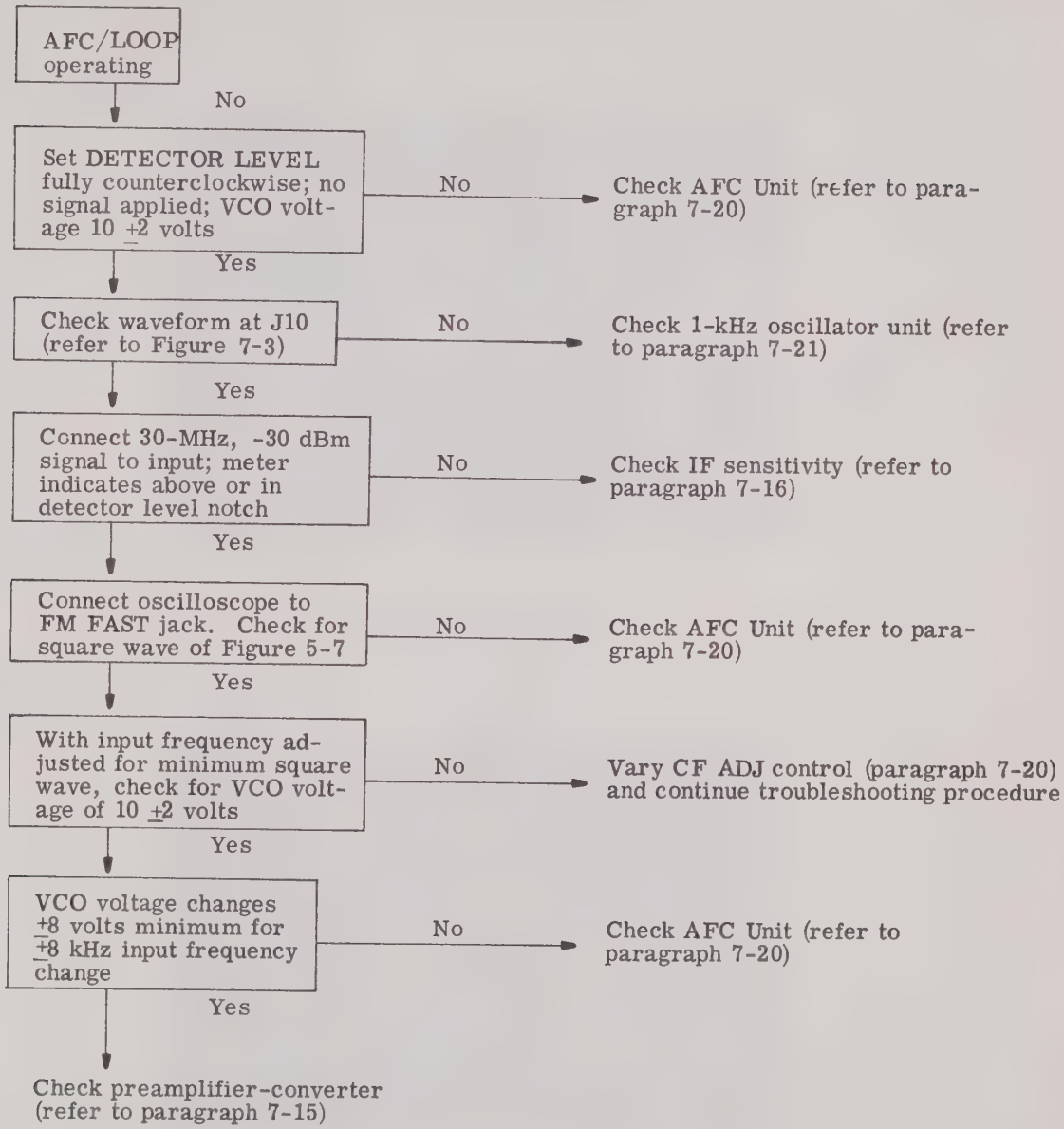
7-6 No AFC Indication

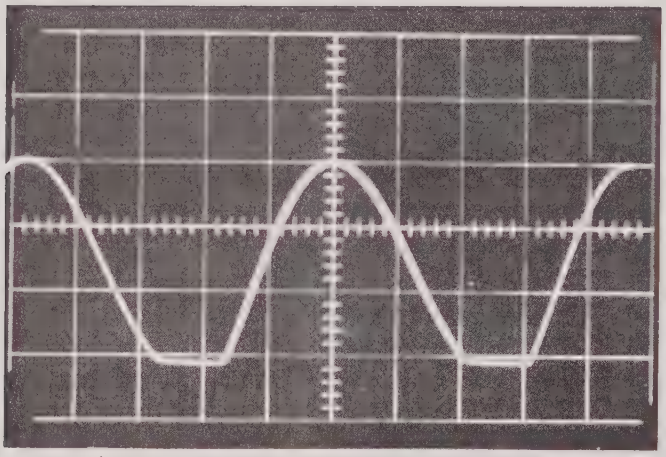

AFC indicator comes on
No
With no signal applied, adjust all front panel controls fully clockwise
Yes
In REFERENCE NORM position, greater than full-scale indication is obtained
No
Check for loss of sensitivity (refer to paragraph 7-16)
Yes
Check for approximately 40 volts at junction of R912 and DS906
No
If voltage is near zero replace lamp DS906
Yes
Check for approximately -13 volts at audio amplifier
No
Check voltage doubler circuit (refer to paragraph 5-8)
Yes
Check audio amplifier module (refer to paragraph 7-19)

7-7 No AFC Indication at Very Low Signal Levels (-115 dBm) (Refer to Figure 5-21)


AFC indicator comes on with low signal levels
No
AFC indicator comes on with high signal levels
No
Refer to paragraph 7-6
Yes
Noise Set
No
Refer to paragraph 4-7
Yes
Signal and LO frequency set properly
No
Refer to paragraphs 4-4, 4-5, 4-6, 4-19, and 4-20
Yes
In REFERENCE NORM position, meter indicates at least 0 ±20
No
Check for loss of sensitivity (refer to paragraph 7-16)
Yes
Adjust R355 (refer to paragraph 7-19, audio amplifier)

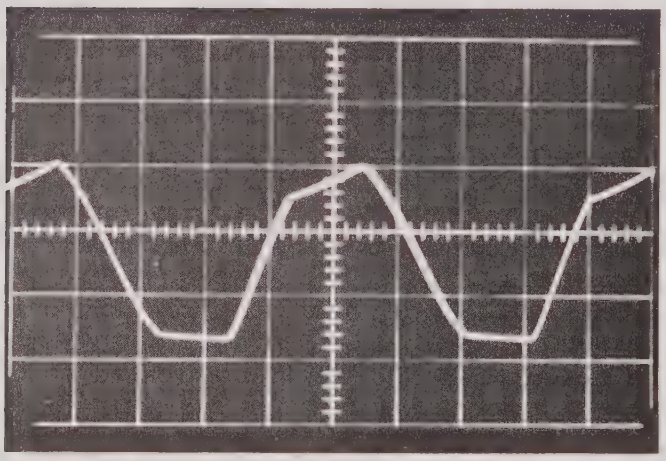
7-8 AFC Indicator Comes On But No Frequency Control


AFC/LOOP operating
No
Set DETECTOR LEVEL fully counterclockwise; no signal applied; VCO voltage 10 ±2 volts
No
Check AFC Unit (refer to paragraph 7-20)
Yes
Check waveform at J10 (refer to Figure 7-3)
No
Check 1-kHz oscillator unit (refer to paragraph 7-21)
Yes
Connect 30-MHz, -30 dBm signal to input; meter indicates above or in detector level notch
No
Check IF sensitivity (refer to paragraph 7-16)
Yes
Connect oscilloscope to FM FAST jack. Check for square wave of Figure 5-7
No
Check AFC Unit (refer to paragraph 7-20)
Yes
With input frequency adjusted for minimum square wave, check for VCO voltage of 10 ±2 volts
No
Vary CF ADJ control (paragraph 7-20) and continue troubleshooting procedure
Yes
VCO voltage changes ±8 volts minimum for ±8 kHz input frequency change
No
Check AFC Unit (refer to paragraph 7-20)
Yes
Check preamplifier-converter (refer to paragraph 7-15)



A. P10 NOT CONNECTED TO J10

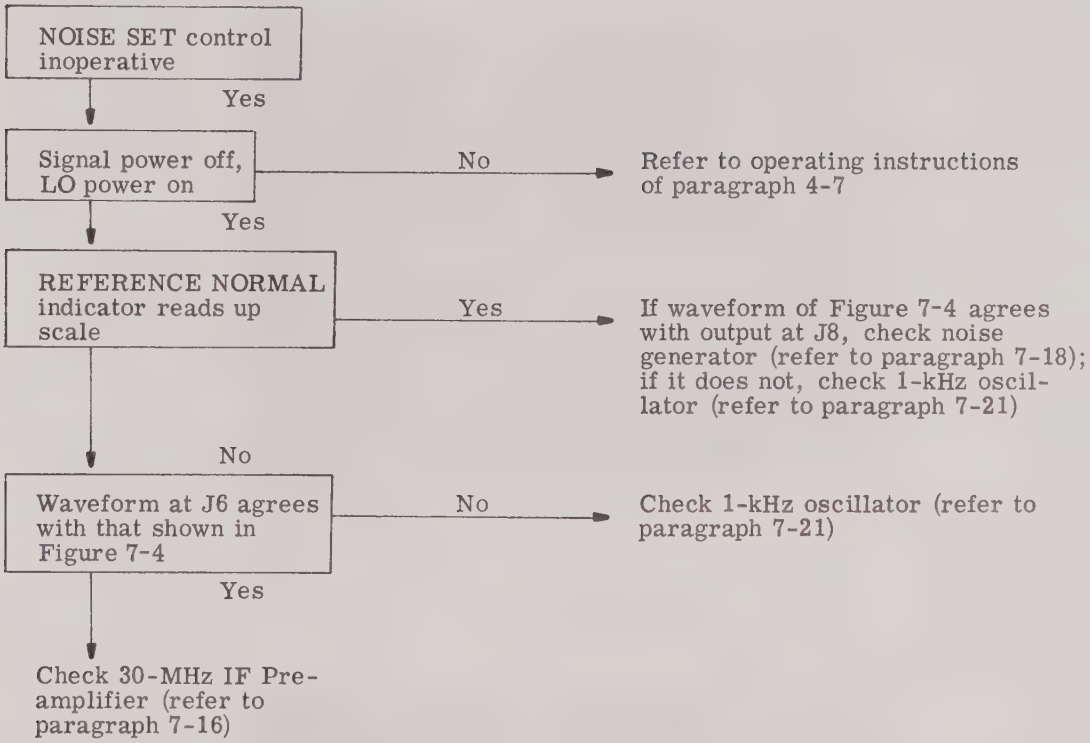
HORIZONTAL 200 USEC/CM
VERTICAL 5.0 V/CM

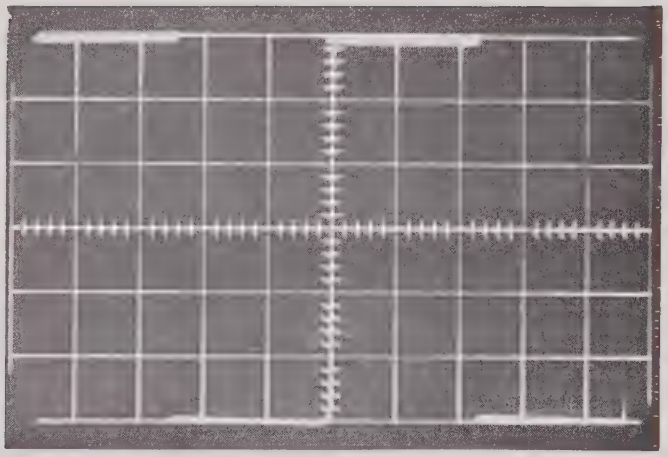


B. P10 CONNECTED J10

FIGURE 7-3. WAVEFORMS AT P10

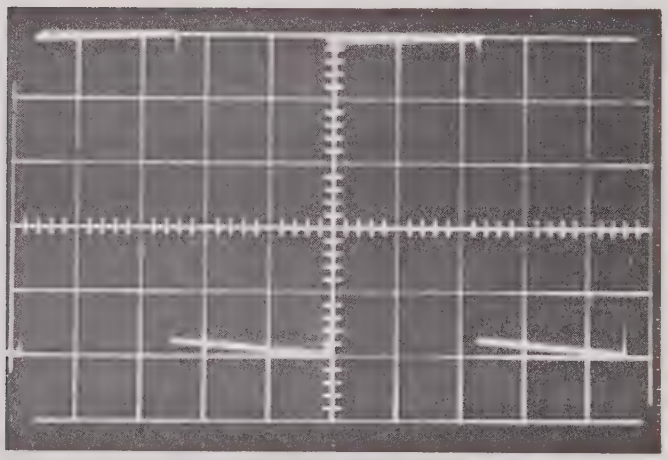
7-9 NOISE SET Control Inoperative


NOISE SET control inoperative
Yes
Signal power off, LO power on
No
Refer to operating instructions of paragraph 4-7
Yes
REFERENCE NORMAL indicator reads up scale
Yes
If waveform of Figure 7-4 agrees with output at J8, check noise generator (refer to paragraph 7-18); if it does not, check 1-kHz oscillator (refer to paragraph 7-21)
No
Waveform at J6 agrees with that shown in Figure 7-4
No
Check 1-kHz oscillator (refer to paragraph 7-21)
Yes
Check 30-MHz IF Preamplifier (refer to paragraph 7-16)



A. J6,8 NOT CONNECTED P8,6

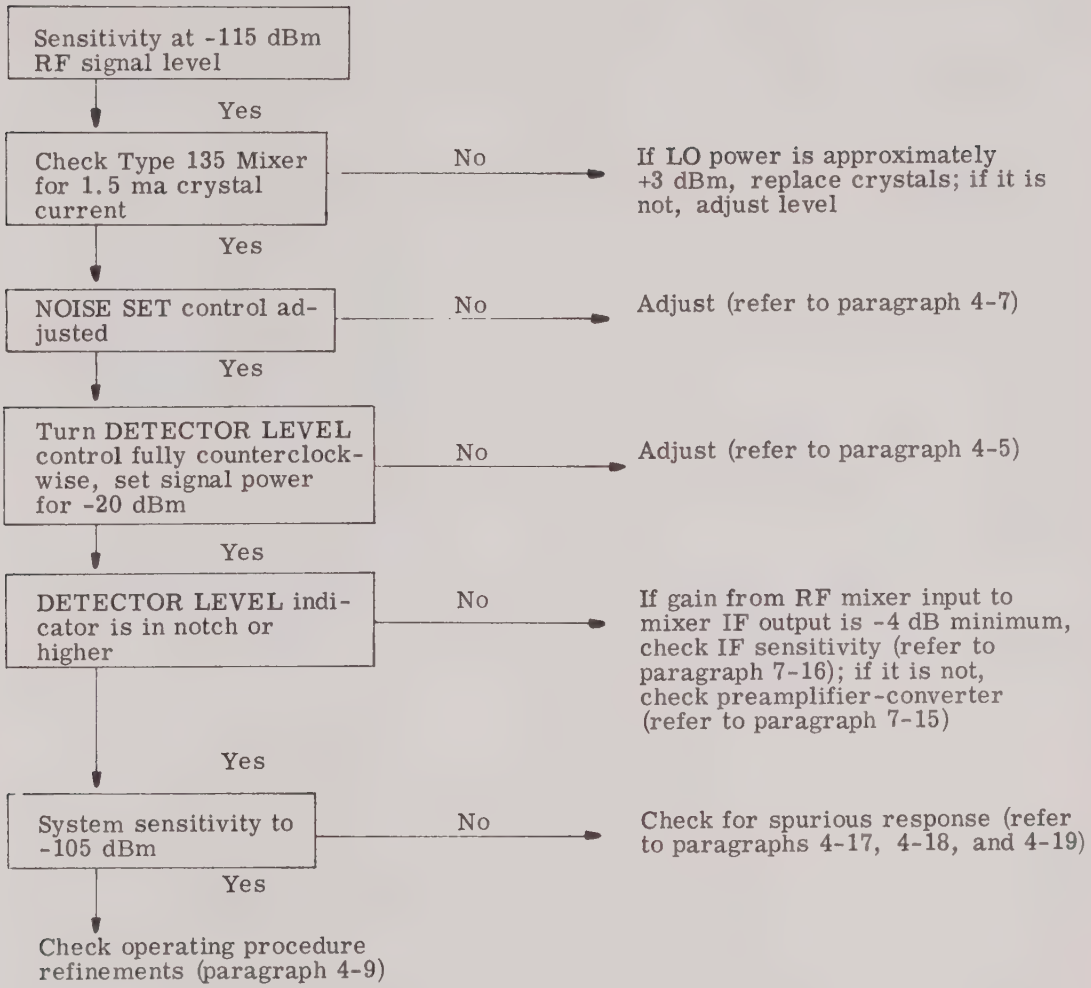
HORIZONTAL 200 USEC/CM
VERTICAL 2.0 V/CM



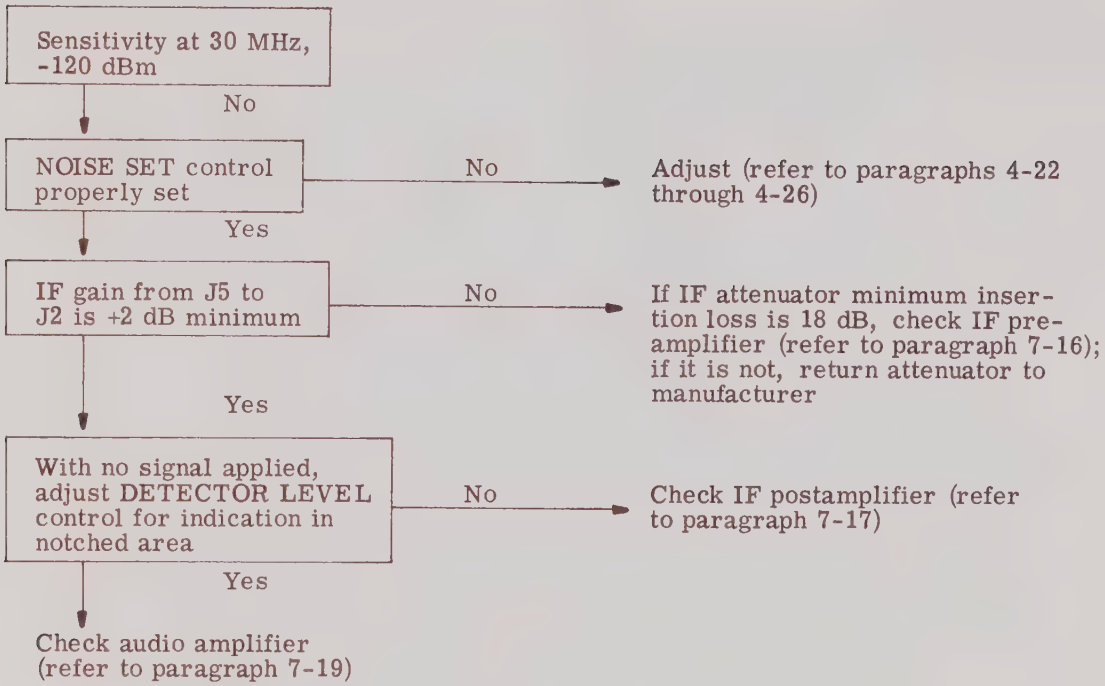
B. J8,6 CONNECTED TO P8,6

FIGURE 7-4. WAVEFORMS AT J8 AND J6

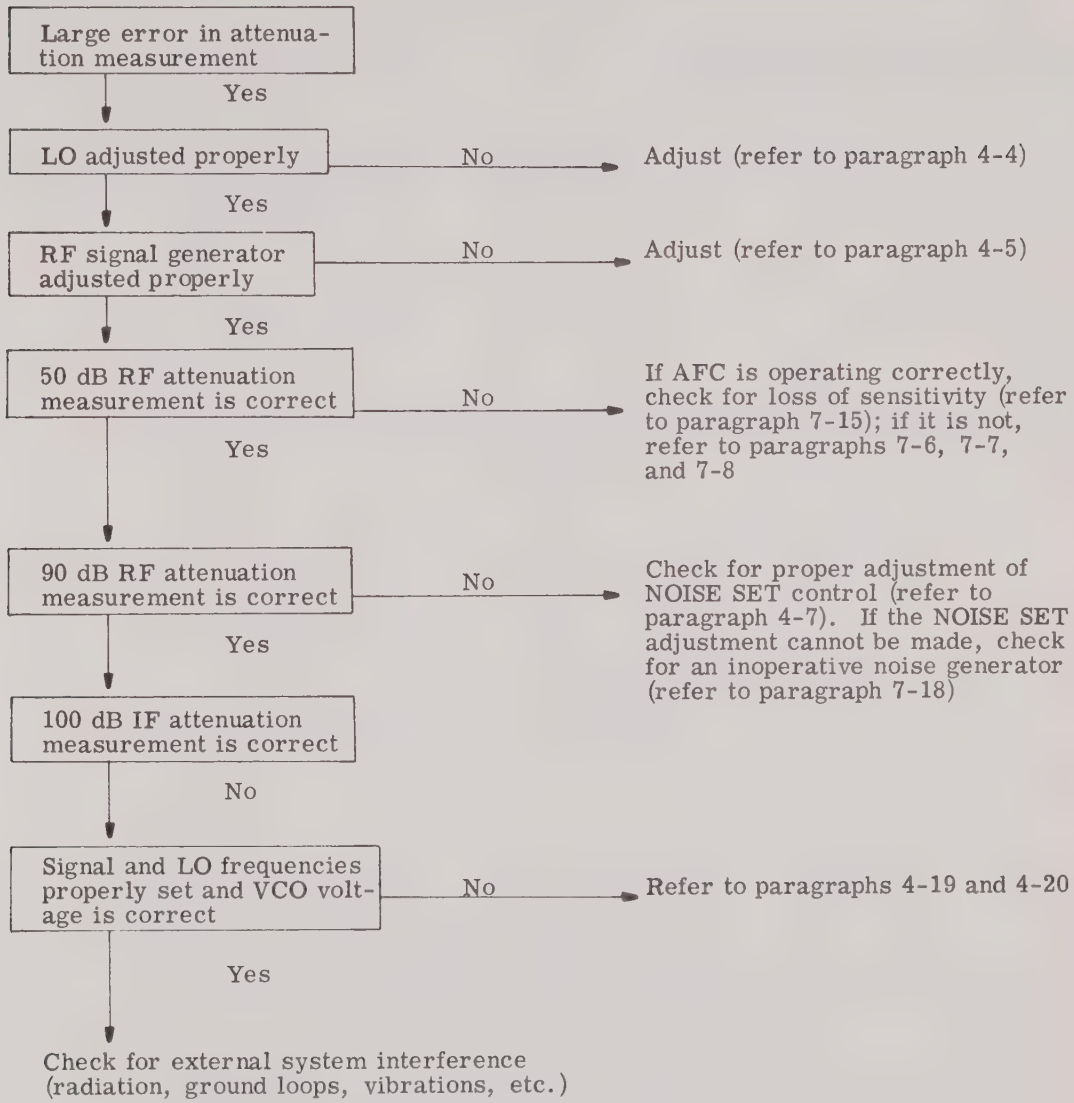
7-10 Loss of Sensitivity


Sensitivity at -115 dBm RF signal level
Yes
Check Type 135 Mixer for 1.5 ma crystal current
No
If LO power is approximately +3 dBm, replace crystals; if it is not, adjust level
Yes
NOISE SET control adjusted
No
Adjust (refer to paragraph 4-7)
Yes
Turn DETECTOR LEVEL control fully counterclockwise, set signal power for -20 dBm
No
Adjust (refer to paragraph 4-5)
Yes
DETECTOR LEVEL indicator is in notch or higher
No
If gain from RF mixer input to mixer IF output is -4 dB minimum, check IF sensitivity (refer to paragraph 7-16); if it is not, check preamplifier-converter (refer to paragraph 7-15)
Yes
System sensitivity to -105 dBm
No
Check for spurious response (refer to paragraphs 4-17, 4-18, and 4-19)
Yes
Check operating procedure refinements (paragraph 4-9)

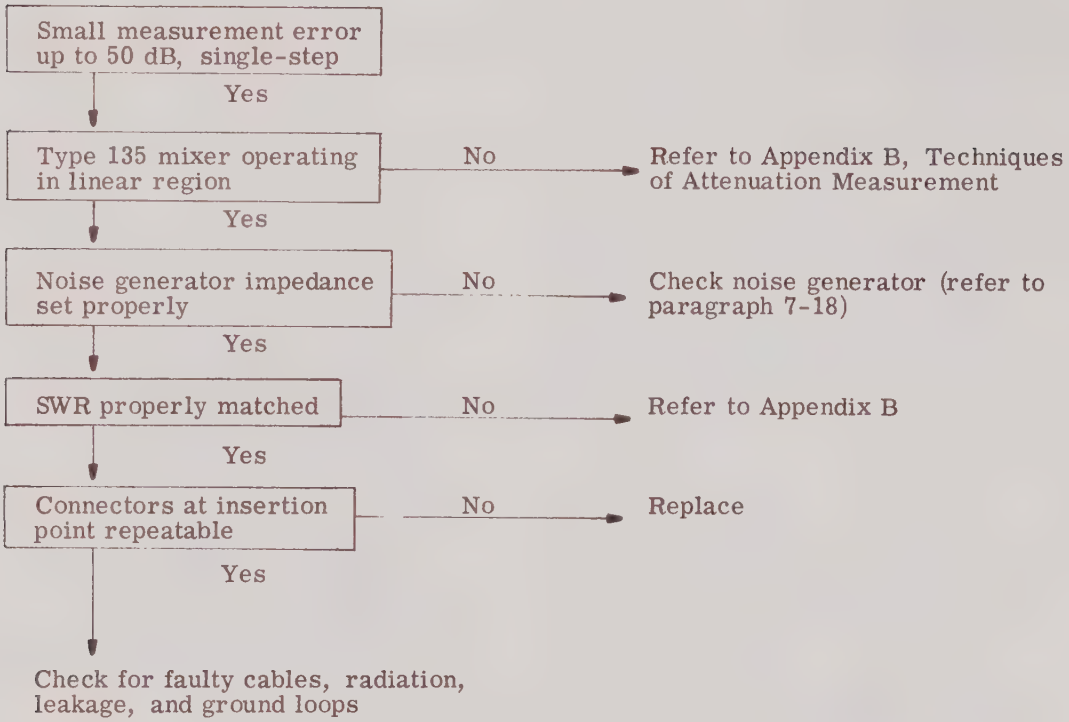
7-11 Loss of IF Sensitivity


Sensitivity at 30 MHz, -120 dBm
No
NOISE SET control properly set
No
Adjust (refer to paragraphs 4-22 through 4-26)
Yes
IF gain from J5 to J2 is +2 dB minimum
No
If IF attenuator minimum insertion loss is 18 dB, check IF preamplifier (refer to paragraph 7-16); if it is not, return attenuator to manufacturer
Yes
With no signal applied, adjust DETECTOR LEVEL control for indication in notched area
No
Check IF postamplifier (refer to paragraph 7-17)
Yes
Check audio amplifier (refer to paragraph 7-19)

7-12 Large Error in Attenuation Measurement


Large error in attenuation measurement
Yes
LO adjusted properly
No
Adjust (refer to paragraph 4-4)
Yes
RF signal generator adjusted properly
No
Adjust (refer to paragraph 4-5)
Yes
50 dB RF attenuation measurement is correct
No
If AFC is operating correctly, check for loss of sensitivity (refer to paragraph 7-15); if it is not, refer to paragraphs 7-6, 7-7, and 7-8
Yes
90 dB RF attenuation measurement is correct
No
Check for proper adjustment of NOISE SET control (refer to paragraph 4-7). If the NOISE SET adjustment cannot be made, check for an inoperative noise generator (refer to paragraph 7-18)
Yes
100 dB IF attenuation measurement is correct
No
Signal and LO frequencies properly set and VCO voltage is correct
No
Refer to paragraphs 4-19 and 4-20
Yes
Check for external system interference (radiation, ground loops, vibrations, etc.)

7-13 Small Error in Attenuation Measurement



7-14 MAINTENANCE AND TROUBLESHOOTING OF SUBSYSTEM MODULES

The modules have been designed so that they may be individually removed from the chassis, when required, without removing an adjacent module. Each module has its own DC supply voltage cable. Examination of the electronics circuitry in a module can be accomplished by removing the top cover (component side) or by removing the bottom cover (printed-circuit board). In the event a component proves to be defective, it can be replaced without removing the printed-circuit board from the module enclosure.

7-15 Preamplifier Converter

No Output

a. Check the DC current flowing into the module; it should be 60 ±10 ma.

b. Check the voltage at the interconnection of L721 and C728; it should be 15 ±0.5 volts. If it is not, check the voltage of each transistor stage according to the voltage chart of Table 8-7.

No Crystal Current

a. Measure the DC resistance between each input clip and ground; it should measure 100 ohms. If it does not, trace the crystal current line according to the schematic diagram of Figure 5-11.

b. Check for continuity between the input clips and pins 5 and 6 on the connector according to the schematic diagram of Figure 5-11. Visually inspect the connector pins for damage.

Loss of Sensitivity

a. Connect a 13508 mixer to the preamplifier-converter. Operate the mixer at an LO frequency of approximately 200 MHz, and at a signal level of -10 dBm at 130 MHz. Measure the IF power output of the converter. It should be approximately -14 dBm. (An RF voltmeter can be used for this measurement.) If the IF output is below -16 dBm, troubleshoot the IF preamplifier in accordance with the voltage chart of Table 8-7 and the theory of operation, paragraph 5-9.

b. A loss of gain can occur because of a malfunction in the mixer. Check the RF voltage (using a high-impedance probe) at the junction of C727 and T704; it should be 0.5 volt. If it is less than 0.32 volt, inspect transformers T704 and T703 for an open connection and check diodes CR702, CR703, CR704, and CR705.

7-16 IF Preamplifier

No Output

a. Check the amount of DC current flowing into the module; it should be 110 ±15 ma.

b. Check the DC voltages according to the voltage chart of Table 8-2.

No Modulated Output

a. Connect a 30-MHz, -30 dBm signal to the receiver input.

b. Measure the power at the preamplifier IF output.

c. Disconnect the preamplifier trigger input. The power at the IF output should decrease by at least 30 dB. If it does not, troubleshoot the IF switch according to the theory of operation paragraph 5-10.

Loss of Sensitivity

Check the IF gain of the preamplifier. A DC voltage of +5 volts should be connected to P6. The gain should be greater than 19 dB. If it is not, troubleshoot the preamplifier according to the voltage chart of Table 8-2 and the theory of operation paragraph 5-10.

7-17 IF Postamplifier

The schematic diagram of the postamplifier is shown in Figure 5-17. Because of the long-term stability of this solid-state amplifier, all tuning adjustments are permanently secured. Returning or other major repairs can best be handled by the manufacturer. However, when this is not practical, the following maintenance procedure may be used.

a. Connect a 30-MHz signal generator to the receiver input. Set the generator to -90 dBm, CW.

b. Turn the receiver gain to a maximum detector level. The meter should deflect to greater than the red notched area. If it does not, determine the generator output level that will result in a deflection within the red notched area. If the generator output is approximately -65 dBm or lower, check for a malfunction of transistors Q1 through Q5 and Q7, in accordance with the DC voltage chart of Table 8-1 and the theory of operation paragraph 5-13.

7-18 Noise Generator

No Output

a. Connect a 30-MHz signal generator to test connector J13. Set the generator output at -40 dBm.

b. Place a jumper between the feedthru (marked "to relay") and ground. Connect a -5 volt DC power supply to the noise generator trigger P8.

c. Measure the IF output of the noise generator. If the output is significantly less than -25 dBm, check the DC voltages according to the voltage chart of Table 8-5. Refer to the theory of operation paragraph 5-12 and the schematic diagram Figure 5-15.

No Modulated Output

Reverse the polarity of the DC supply connected to P8; the output should drop at least 40 dB. If it does not, check the switching circuit according to the theory of operation paragraph 5-12 and the voltage chart of Table 8-5.

7-19 Audio Amplifier

The block diagram and schematic diagram of the audio amplifier are shown in Figures 5-20 and 5-21. Because of the long-term stability of this solid-state amplifier, there are very few tuning adjustments. Any major repairs can best be handled by the manufacturer.

No Output

a. Connect a 30-MHz, -40 dBm signal to the IF input of the receiver. Set the front panel controls according to the RF measurement procedure of Section IV.

b. Connect an oscilloscope to the 1-kHz monitor J11. The voltage at this point should be a sinewave of approximately 50 to 100 mv peak-to-peak. If no signal is present, check the amplifier according to the theory of operation paragraph 5-15 and the DC voltage chart of Table 8-3.

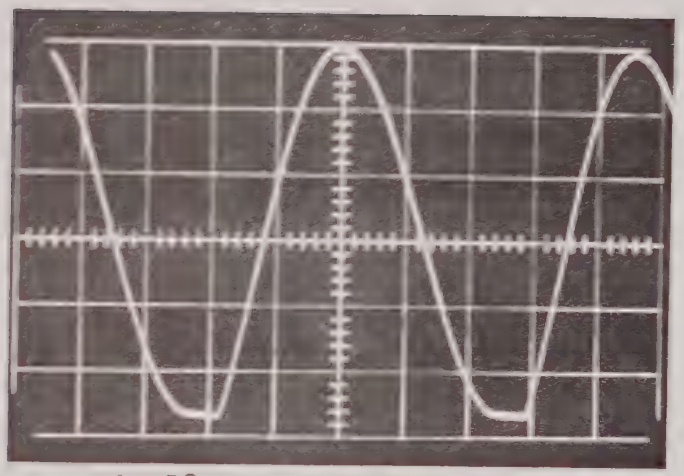
c. If a voltage exists at J11 and the waveform at J9 agrees with Figure 7-5 but no output exists at REFERENCE NORM, check the detector consisting of CR305 through CR308. If no output exists at REFERENCE EXP, check the detector consisting of CR313 and CR314.

No AFC Light Indication

If the AFC light does not illuminate under any instrument operating condition, check the amplifier stages consisting of Q306 and Q307, the detector consisting of CR309 through CR312, and the driver stages consisting of Q308 through Q313. Refer to the DC voltage chart of Table 8-3 and the theory of operation paragraph 5-15.

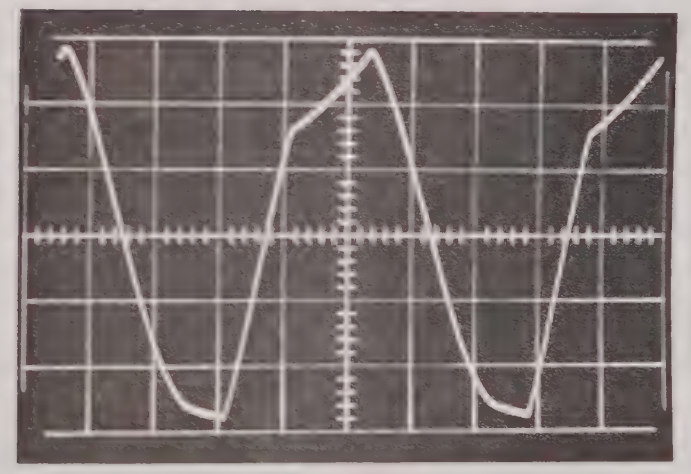
7-20 AFC Unit

The schematic and block diagrams of the AFC unit are shown in Figures 5-18 and 5-19. Because of the long-term stability of this solid-state amplifier, all tuning adjustments are permanently secured. Retuning or other major repairs can best be handled by the manufacturer. However, when this is not practical, the following maintenance procedure may be used.



A. P9 NOT CONNECTED TO J9

HORIZONTAL 200 USEC/CM
VERTICAL 2.0 V/CM



B. P9 CONNECTED TO J9

FIGURE 7-5. WAVEFORMS AT P9

a. Connect a 30-MHz signal generator to the receiver input. Set the generator to -40 dBm output and adjust the front panel controls according to the RF measurement procedure of Section IV.

b. Decrease the generator output by approximately 50 dB. The VCO voltage (FM SLOW) should be 10 ±2 volts. If it is not, check the DET OUT voltage; it should be 0 volt. If it is 0 volt, slowly vary the CF ADJ control for a 10.0-volt VCO reading. If the DET OUT voltage is not 0 volt, check the discriminator and coherent detector circuitry according to the theory of operation paragraph 5-14, the block diagram and schematic diagram Figures 5-18 and 5-19, and the DC voltage chart of Table 8-4.

7-21 1-kHz Oscillator

a. There are five outputs of this solid-state oscillator.

1. J6 is a 1-kHz square wave, 8 volts peak-to-peak. minimum.
2. J8 is a 1-kHz square wave, 8 volts peak-to-peak minimum when S903 is open and at ground potential when S903 is closed.
3. P9 is a 1-kHz sinewave, 10 volts peak-to-peak nominal.
4. P10 is a 1-kHz sinewave, 10 volts peak-to-peak nominal.
5. The noise generator switch output is at ground potential when S903 is open and is at one-half the peak-to-peak voltage of J8 when it is closed.

b. If the outputs are not as described above, refer to the theory of operation paragraph 5-16 and the schematic and block diagrams of Figures 5-22 and 5-23. The voltage chart of Table 8-6 can also be used as a troubleshooting reference.

7-22 ROUTINE MAINTENANCE

7-23 Precision Attenuator

Maintenance of the precision attenuator is limited to semiannual lubrication of the drive mechanism. Crank the piston out about 1/2-inch from the fully seated position, then apply one drop of light instrument oil to the bearings and the piston. To distribute the oil, turn the drive shaft so that the piston is moved in and out over its full range.

CAUTION

Do not use an excessive amount of oil. Oil inside the piston or the sleeve can cause electrical malfunction. Do not attempt to disassemble the unit or make gear train adjustments. Return the unit to the manufacturer for any repairs.

A certificate of calibration for the precision attenuator may be obtained through the use of the facilities of the National Bureau of Standards. Current information regarding calibration fees, testing methods, measurement accuracy, shipping instructions, etc., may be obtained from the National Bureau of Standards, Boulder, Colorado.

7-24 Disassembly of Precision Attenuator

a. Set the attenuator dial near 100 dB.

b. Remove the cylindrical collar on the movable piston assembly by rotating it in a counterclockwise direction. Use a wrench to hold the mating threaded part; it is important to prevent this part from rotating.

c. Disconnect the coaxial cable from the two TNC connectors.

d. Loosen the screws that hold the mounting bracket for the microswitch and remove the bracket and switch. Retighten the screws.

e. Remove the attenuator knob and unscrew the two front panel mounting screws. The attenuator is now completely disassembled from the unit.

7-25 Noise Generator

Maintenance of the noise generator is limited to checking the impedance match of the electronic switch. The switch is designed so that its output impedance is the same in the open and closed positions.

a. Remove the receiver from the cabinet and connect a 30-MHz, -40 dBm, CW signal to the IF IN jack on the receiver front panel.

b. Adjust the front panel controls according to the operating instructions for IF attenuation measurements.

c. In the REFERENCE EXP position, note the position of the meter needle. Close the attenuator switch S903 by lightly pressing down on the contact arm. The position of the meter needle should not change by more than 1 division. If the change is greater, adjust R516 (located on the right side of the chassis). R516 should be adjusted with the attenuator switch S903 in the open position.

NOTE

The accuracy of this adjustment depends on the amplitude stability of the 30-MHz source; therefore, allow sufficient source warmup time.

7-26 1-kHz Oscillator

Maintenance of the 1-kHz oscillator is limited to checking the frequency of oscillation, square-wave symmetry, and peak-peak voltage output.

a. Connect a counter to P10 and observe the frequency reading; it should be 1000 ±5 Hz, if it is not, adjust R611.

b. Observe the peak-to-peak voltage at this point; it should be 10 volts minimum. If it is not, adjust R604. After this adjustment, recheck the frequency reading.

c. Check the symmetry of the square wave by connecting an oscilloscope to J6. The symmetry should be within 2 percent. If it is not, adjust R624.

7-27 AFC Unit

Maintenance of the AFC detector is limited to checking the balance of the coherent detector and the quiescent point of Q410, the VCO voltage.

a. Disconnect the IF input P4 and measure the voltage at the DET OUT jack on the back of the receiver; it should be 0 volt. If it is not, adjust R457 for a 0 volt output.

b. When the output of the detector is 0 volt, the VCO voltage should be 10 volts. If it is not, adjust the CF ADJ control on the back of the receiver.

7-28 Audio Amplifier

Maintenance of the audio amplifier is limited to checking the balance of the two coherent detectors and the triggering level for the AFC light.

a. Disconnect the video input P3 and measure the voltage at the zero-set terminal; it should be 0 volt. If it is not, adjust R388. In the REFERENCE NORM position, the meter should read 0 (NOISE SET); if it is not, adjust ~~R343~~ 337. Reconnect the video input cable.

b. Connect a 30-MHz, -40 dbm, CW signal to the IF IN jack on the receiver front panel. Adjust the front panel controls according to the operating instructions for IF attenuation measurements.

c. Adjust the REFERENCE control so that the meter indicator pointer (REFERENCE NORMAL position) lies in the DET LEV notch. The AFC light should be illuminated. Adjust R356 so that the light illuminates when the meter indicator is in the DET LEV notch or higher.

7-29 FACTORY REPAIR

If it is necessary to return the equipment to the factory for repair, please follow these instructions.

a. Write to the AIL Microwave Instruments Department, giving complete information concerning the failure and the manner in which the equipment was being used when failure occurred. Include the unit TYPE and SERIAL numbers.

b. Special shipping instructions will be supplied by AIL. Pack and ship the equipment as directed. Transportation charges should be prepaid, and a failure report should be supplied with the equipment.

SECTION VIII
DC VOLTAGE TABLES

8-1 GENERAL

The normal operating voltages listed in these tables are useful in locating an area of abnormal operation within the individual modules. The following notes are applicable.

1. The voltages should be measured with a high-impedance voltmeter (greater than 100,000 ohms-per-volt).
2. All voltages should be measured with respect to ground.
3. Measured values of voltages should be within +20 percent of those listed.
4. Measurement points are identified as follows:

Q701 V_B	Base of transistor Q701
C704	One terminal of C704 (the other terminal is grounded)
R624/R625	Junction of R624 and R625

The tables for the individual modules are as follows:

8-1	30-MHz Postamplifier
8-2	30-MHz Preamplifier
8-3	Audio Amplifier
8-4	AFC Unit
8-5	Noise Generator
8-6	1-kHz Oscillator
8-7	Preamplifier-Converter

TABLE 8-1. 30-MHz POSTAMPLIFIER DC VOLTAGE TABLE

Component	V_B	V_E	V_C	Other	Notes
Q1	4.8	5.0	0		
Q2	3.8	4.0	0		
Q3	3.8	4.0	0		
Q4	3.8	4.0	0		
Q5	10.2	10.8	0		
Q6	13.0	12.0	20		
Q7	13.0	12.0	20		
C42				20.0	
C26				20.0	
C20				7.6	
C6				7.6	
C17				0.75	Detector level control fully counterclockwise
C17				0	Detector level control fully clockwise

TABLE 8-2. 30-MHz PREAMPLIFIER DC VOLTAGE TABLE

Component	V_B	V_E	V_C	Other	Notes
Q201	4.2	3.6	16		
Q202	15.0	14.4	40		
Q203	8.0	7.4	40		
Q204	8.0	7.4	40		
C203				15.0	
C207				16.0	
C210				27.0	
C211				40.0	
C229				40.0	
C227				5.0	
CR203/ CR202				5.0	
CR201				5.0	Disconnect cable at PULSE IN connector and apply +5 VDC at connector
C224				0	
C221				4.6	
C218				4.6	

TABLE 8-3. AUDIO AMPLIFIER DC VOLTAGE TABLE

Component	V_B	V_E	V_C	Other	Notes
FET Q302	$V_G = 0$	$V_S = 2$	$V_D = 18$		
FET Q303	$V_G = 4$	$V_S = 5$	$V_D = 20$		
Q301	1.3	0.7	12.0		
Q304	1.5	0.9	10.0		
Q305	9.5	8.9	20.0		
Q306	1.1	0.5	11.0		
Q307	9.5	8.9	20.0		
Q308	0	-0.6	18.0		
Q309	0	-0.6	15.0		
Q310	15.0	14.5	20.0		
Q311	18.0	14.5	14.2		AFC indicator light is illuminated
Q312	14.2	8.8	0.5		
Q313	8.0	8.8	8.6		
Q314	0.7	0	0.1		
Q308	0	-0.6	18.0		
Q309	0	-0.6	8.5		
Q310	8.5	12.5	20.0		AFC indicator light is not illuminated (disconnect 1-kHz reference)
Q311	15.0	12.5	8.0		
Q312	8.0	9.0	9.0		
Q313	8.0	9.0	0		
Q314	0	0	40.0		
C301				40.0	
C302				20.0	REFERENCE COARSE and REFERENCE FINE controls fully clockwise
CR303				0.6	
CR304				0.6	
C302				0	REFERENCE COARSE and REFERENCE FINE controls fully counterclockwise
C303				0	
C304				3.5	

TABLE 8-4. AFC UNIT DC VOLTAGE TABLE

Component	V_B	V_E	V_C	Other	Notes
Q401	8.2	8.4	0		
Q402	8.2	8.4	0		
Q403	10.5	10.9	0		
Q405	1.3	0.7	12.0		
Q408	1.5	0.9	10.0		
Q409	10.0	9.6	20.0		
FET Q404	$V_G = 2.5$	$V_S = 5$	$V_D = 20$		
FET Q406	$V_G = 0$	$V_S = 2$	$V_D = 18$		
FET Q407	$V_G = 4$	$V_S = 5$	$V_D = 20$		
FET Q410	$V_G = 0$	$V_S = 1$	$V_D = 10$		1-kHz reference removed
C447				40.0	
C339				20.0	
C421				20.0	
C438				3.5	

TABLE 8-5. NOISE GENERATOR DC VOLTAGE TABLE

Component	V_B	V_E	V_C	Other	Notes
Q501	12.0	12.3	0		
Q502	12 0	12.3	0		
Q503	12.0	12.3	0		
C521				40.0	
C532				40.0	
C519				15.0	
C503				15.0	
C526				5.0	+5 VDC connected to "to relay" terminal, PULSE IN disconnected--or noise generator in system, attenuator set to 40 dB reading
C531				0	
C528				0.6	
C525				0.6	
C501				0	NOISE SET control fully clockwise
C501				8.0	NOISE SET control fully counter-clockwise
C508				0.5	

TABLE 8-6. 1-kHz OSCILLATOR DC VOLTAGE TABLE

Component	V_B	V_E	V_C	Other	Notes
Q601	1.1	0.5	10.0		
Q602	10.0	9.4	25.0		
Q603	9.4	8.8	22.5		
Q604	8.8	8.2	20.0		
Q605	8.8	8.2	20.0		
Q606	0.6	0	2.0		
Q607	0.3	0.9	9.0		
Q608	9.0	8.4	20.0		
Q609	9.0	8.4	20.0		
C601				40.0	
R625/R624				5.5	
C615				20.0	
R635/K601				40.0	Relay not energized, attenuator set <25
R635/K601				5.0	Relay energized, attenuator set >35

TABLE 8-7. PREAMPLIFIER-CONVERTER (13730) DC VOLTAGE TABLE

Component	V_B	V_E	V_C	Other	Notes
Q701	4.5	4.2	15.0		
Q702	4.5	4.2	15.0		
Q703	12.1	12.3	0		
R721/pin 7				40.0	
CR707				15.0	
C716				15.0	
C704				15.0	
C723				15.0	

APPENDIX A

ACCESSORY ITEMS AVAILABLE FOR USE WITH TYPE 137 RF ATTENUATION CALIBRATOR

		P/N
TYPE 32 PRECISION IF ATTENUATOR		
30 MHz Unmounted		03230
30 MHz Rack Mounted		03231
30 MHz Case Mounted		03232
60 MHz Unmounted		03260
60 MHz Rack Mounted		03261
60 MHz Case Mounted		03262
TYPE 70 NOISE GENERATORS		
Hot/Cold Standard	0 - 6.0 GHz	07004
Selection to	0 - 7.0 GHz	07004SP
Diode	10 - 250 MHz	07006
Coaxial (Argon)	0.2 - 2.6 GHz	07010
Same as 07010 with HN Conn.		07011
Coaxial (Argon)	2.0 - 5.0 GHz	07012
Waveguide (Argon)	2.6 - 3.95 GHz	07048T
Waveguide (Argon)	3.95 - 5.85 GHz	07049T
Waveguide (Argon)	5.85 - 8.20 GHz	07050T
Waveguide (Argon)	7.05 - 10.0 GHz	0.051T
Waveguide (Argon)	8.2 - 12.4 GHz	07052T
Waveguide (Argon)	12.0 - 18.0 GHz	07091T
Waveguide (Argon)	18.0 - 26.5 GHz	07053T
Waveguide (Argon)	26.5 - 40.0 GHz	07096
TYPE 71 NOISE GENERATOR POWER SUPPLY		
Power Supply for Argon Noise Generator		07111
Rack Mounting Adapter for 07111		204946
TYPE 125 POWER SIGNAL SOURCE		
Power Signal Source		12511

					P/N
TYPE 135 COAXIAL MIXERS					
Mixer	0.125	-	0.5	GHz	13510
Mixer	0.01	-	1.0	GHz	13508
Mixer	1.0	-	2.0	GHz	13504
Mixer	2.0	-	4.0	GHz	13505
Mixer	3.6	-	4.2	GHz	13509
Mixer	4.0	-	8.0	GHz	13506
Mixer	7.0	-	11.0	GHz	13507
TYPE 135 WAVEGUIDE MIXERS					
Mixer	3.7	-	4.2	GHz	13522
Mixer	4.4	-	5.0	GHz	13523
Mixer	5.4	-	5.9	GHz	13524
Mixer	5.9	-	6.5	GHz	13525
Mixer	6.5	-	7.5	GHz	13526
Mixer	7.5	-	8.5	GHz	13527
Mixer	8.2	-	12.4	GHz	13546
Mixer	8.5	-	9.6	GHz	13528
Mixer	8.8	-	10.25	GHz	13529
Mixer	10.0	-	12.4	GHz	13531
Mixer	12.4	-	14.0	GHz	13532
Mixer	12.4	-	18.0	GHz	13547
Mixer	13.5	-	15.6	GHz	13533
Mixer	15.0	-	17.0	GHz	13534
Mixer	17.0	-	19.6	GHz	13541
Mixer	19.7	-	23.0	GHz	13545
Mixer	23.0	-	25.0	GHz	13538
Mixer	25.0	-	29.0	GHz	13542
Mixer	29.0	-	34.0	GHz	13543
Mixer	34.0	-	36.0	GHz	13539
Mixer	36.0	-	40.0	GHz	13544
TYPE 136 PREAMPLIFIER					
Low Noise Preamplifier					13630
Impedance Adapter, 50 ohm					208393
Impedance Adapter, 150 ohm					208550

					P/N
TYPE 210 SWEEP OSCILLATOR					
Main Frame					21010
External PIN Leveled Plug-Ins:	0.5	-	1.0	GHz	21030
	1.0	-	2.0	GHz	21031
	1.0	-	2.6	GHz	21032
	1.7	-	4.2	GHz	21033
	2.0	-	4.0	GHz	21034
	3.7	-	8.3	GHz	21035
	4.0	-	8.0	GHz	21036
	7.0	-	12.4	GHz	21037
	8.0	-	12.4	GHz	21038
	12.4	-	18.0	GHz	21039
Internal PIN Leveled Plug-Ins:	1.0	-	2.0	GHz	21040
	1.0	-	2.6	GHz	21041
	1.7	-	4.2	GHz	21042
	2.0	-	4.0	GHz	21043
	3.7	-	8.3	GHz	21044
	4.0	-	8.0	GHz	21045
	7.0	-	12.4	GHz	21046
	8.0	-	12.4	GHz	21047
External Grid Leveled Plug-Ins:	10.0	-	15.0	GHz	21048
	10.0	-	20.0	GHz	21049
	18.0	-	26.5	GHz	21050
	26.5	-	40.0	GHz	21051
TYPE 391 MICROWAVE CRYSTAL TEST SET					
Crystal Test Set					39110

APPENDIX B
TECHNIQUES OF ATTENUATION MEASUREMENT

1. INSERTION-LOSS DEFINITION

The insertion loss of a two-port network can be defined as that decrease in transmitted power that occurs when a uniform transmission line, having a matched source at one end and a matched load at the other end, is interrupted by the insertion of the network. Referring to the circuit of Figure B-1, insertion loss L can be expressed in terms of the relation between the power available from the matched generator P_G and the power absorbed by the matched load P_L. This relation is shown in normalized form in equation A-1.

$$L = 1 - \frac{P_L}{P_G} \tag{B-1}$$

The above definition of insertion loss includes two separate effects: attenuation, and reflection loss. Some of the power entering the network is dissipated within the network. This loss can be defined as the attenuation of the network. In addition, if there is an impedance mismatch at either one or both ports of the network, a portion of the incident power is reflected back toward the generator, causing losses that are referred to as reflection losses.

Insertion loss can be expressed as the sum of these losses:

$$L = L_A + L_i + L_o \tag{B-2}$$

where

L = Insertion loss (dB)
L_A = Loss due to attenuation (dB)
L_i = Loss due to mismatch at the attenuator input (dB)
L_o = Loss due to mismatch at the attenuator output (dB)

2. MISMATCH ERRORS IN ATTENUATION MEASUREMENT

The reflection losses at the two ports of the network vary, depending on the actual source and load impedances in the measurement system. These variations cause an uncertainty whose limits can be calculated as follows.

The reflection losses in the matched system of Figure B-1 are equal to

$$L_i = |r_i|^2 \tag{B-3}$$

$$L_o = |r_o|^2 \tag{B-4}$$

where

r_i = Reflection coefficient of attenuator input

r_o = Reflection coefficient of attenuator output

In the practical measurement system (Figure A-2) the reflection losses may differ from the values given above because of the mismatch generator and load. The measured reflection loss at the input port may be either greater or less than the desired value and will fall within the following limits:

$$L_1 = |r_1|^2 \tag{B-5}$$

where

$$r_1 = \frac{S_1 - 1}{S_1 + 1} \tag{B-6}$$

and

$$\frac{S_G}{S_i} \leq S_1 \leq S_G S_i \tag{B-7}$$

L_1 = Measured reflection losses at attenuator input

S_1 = Effective SWR of combination of generator-output and attenuator-input impedances

S_i = SWR of attenuator input impedance

S_G = SWR of generator output impedance

r_1 = Reflection coefficient corresponding to S1

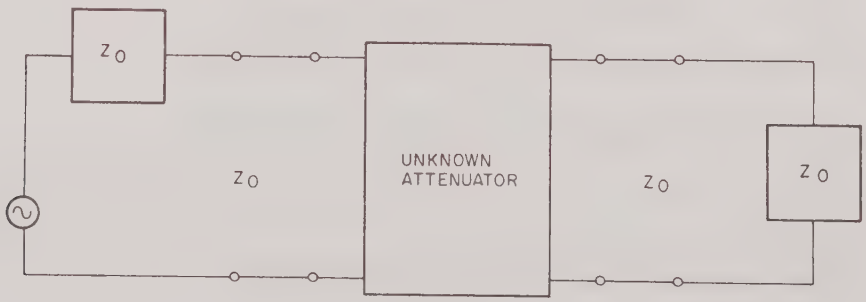


FIGURE B-1. ASSUMED CONDITIONS FOR DEFINITION OF INSERTION LOSS

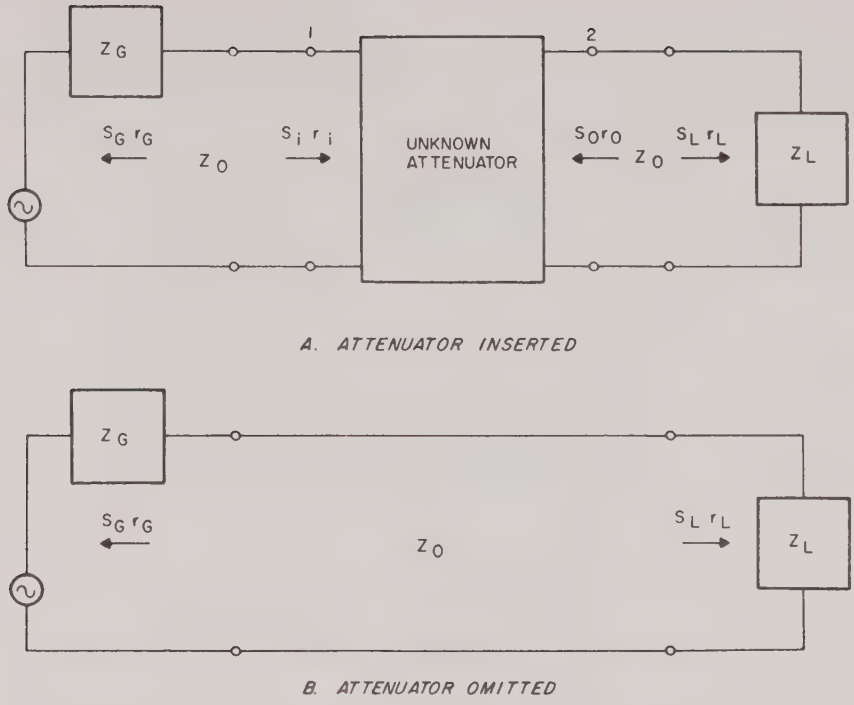


FIGURE B-2. ACTUAL CONDITIONS FOR MEASUREMENT OF INSERTION LOSS

The difference between the measured mismatch loss and the theoretical mismatch loss constitutes an uncertainty E_1.

$$E_1 = L_1 - L_i \tag{B-8}$$

$$E_1 = |r_1|^2 - |r_i|^2 \tag{B-9}$$

Similarly, a corresponding uncertainty in measurement E_2 occurs as a result of the mismatch of the load.

$$E_2 = |r_2|^2 - |r_o|^2 \tag{B-10}$$

where

$$r_2 = \frac{S_2 - 1}{S_2 + 1} \tag{B-11}$$

$$\frac{S_o}{S_L} \leq S_2 \leq S_o S_L \tag{B-12}$$

S_o = SWR of the attenuator output impedance

S_L = SWR of the load impedance

S_2 = Effective SWR of the combination of the load and the attenuator output impedances.
r_2 = Reflection coefficient corresponding to S_2.

When reading the reference power level with the equipment arranged as shown in Figure A-2B, an additional uncertainty in measurement occurs when the generator and load are mismatched;

$$E_R = |r_R|^2 \tag{B-13}$$

where

$$r_R = \frac{S_R - 1}{S_R + 1} \tag{B-14}$$

$$\frac{S_G}{S_L} \leq S_R \leq S_G S_L \tag{B-15}$$

S_R = Effective SWR of the mismatched generator and load
R = Reflection coefficient corresponding to S_R

The combined effect E of the uncertainties described above is equal to:

$$E = \frac{E_1 E_2}{E_R} \tag{B-16}$$

or, when all terms are expressed in db,

$$E' = E'_1 + E'_2 - E'_R \tag{B-17}$$

where

$$E'_1 = 10 \log\left(\frac{1}{1 - E_1}\right) \text{ etc.} \tag{B-18}$$

A calculation of the uncertainty of a measurement is shown in the following example. Assuming:

$$S_G = 1.3$$

$$S_L = 1.16$$

$$S_i = S_o = 1.2$$

From equations B-6 and B-7,

$$0.039 \leq r_1 \leq 0.219$$

$$r_i = 0.0909$$

Then, from equation B-9,

$$-0.006 \leq E_1 \leq 0.040$$

The corresponding dB values can be computed from equation B-18.

$$0.027 \leq E'_1 \leq 0.178 \text{ dB}$$

Similarly, from equations B-10, B-11, B-12, and B-18

$$-0.036 \leq E'_2 \leq 0.085 \text{ dB}$$

and from equations B-13, B-14, B-15, and B-18

$$0.013 \leq E'_R \leq 0.191 \text{ dB}$$

The extreme values of the uncertainty E′ can be found by combining the above values in accordance with equation B-17.

$$E' = 0.178 + 0.085 - 0.013 = 0.250 \text{ dB (maximum positive)}$$

$$E' = 0.027 - 0.036 - 0.043 = -0.0106 \text{ dB (maximum negative)}$$

3. REDUCTION OF MISMATCH ERRORS

The use of a matched attenuator between a mismatched generator or load and the measurement circuit will reduce the SWR of these components. The improved SWR is related to the original SWR as follows:

$$S = \frac{A(S_G + 1) + (S_G - 1)}{A(S_G + 1) - (S_G - 1)} \qquad \text{(B-19)}$$

where

S = Inproved SWR

S_G = Original SWR of the generator (or load)

A = Attenuator loss $\left(\frac{P_{in}}{P_{out}}\right)$

The attenuator should be placed immediately adjacent to the unknown attenuator in order to reduce reflections from all possible sources in the "generator" or "load" sections of the measurement system.

The following example illustrates the improvement obtained in the SWR of a signal generator by the use of a perfectly matched 6-dB attenuator.

If

$$S_G = 3$$

and

$$A = 4$$

then, from equation A-19:

$$S = 1.3$$

Ferrite isolators used in place of the matched attenuators will also provide an improved SWR and, because of their low insertion loss, there will be very little reduction in the attenuation measurement range. The main disadvantages of the ferrite isolators are their high cost and limited frequency range.

An alternative method of reducing the mismatch of the generator and load sections of the measurement system is to use a tuner on each side of the unknown attenuator as shown in Figure B-3.

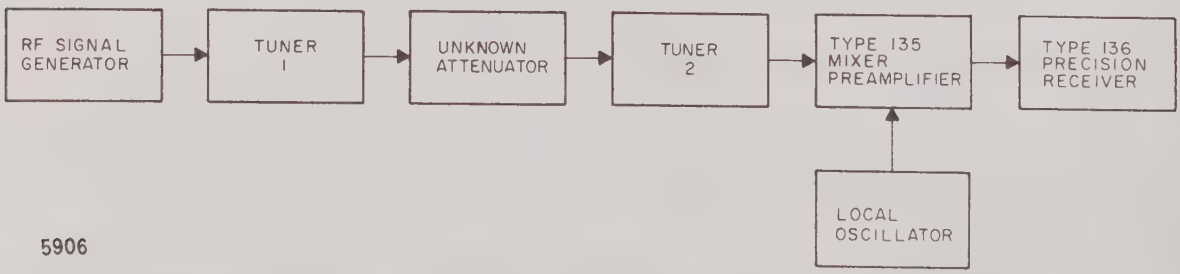


FIGURE B-3. USE OF TUNERS IN ATTENUATION MEASUREMENT

To adjust tuner 2, a slotted line can be inserted in place of the unknown attenuator. The local oscillator should be set to the desired operating frequency and its level adjusted for proper crystal current in the mixer. The RF signal generator should be modulated by 1 kHz to provide a signal for the SWR indicator used with the slotted line. Tuner 2 should then be adjusted until the indicated SWR is reduced to the desired level. An SWR of 1.02 should be obtainable.

Tuner 1 can be adjusted in a similar manner by turning off the RF signal generator, disconnecting tuner 2 from the slotted line, and feeding the output of a second signal generator into this port of the slotted line. The second generator must be tuned to the same operating frequency as the first generator and must be modulated by 1 kHz. If a ferrite isolator is used between the signal generator and tuner 1, the signal generator can be disconnected from the isolator and used as the signal source for the adjustment of tuner 1. In addition, the use of the isolator makes it possible to change the setting of the signal generator output attenuator without readjusting the tuner.

4. SYSTEM NONLINEARITY ERRORS

In any IF-substitution measurement of RF attenuation, the accuracy is dependent upon the linearity of the circuit elements between the unknown attenuator and the precision IF attenuator. The combination of the Type 135 mixer and the Type 136 high-power IF preamplifier has been designed to provide a very wide linear range.

The linearity of the system can be checked by making a series of measurements of a fixed RF attenuator over a range of input signal levels. The procedure is as follows:

1. Measure the attenuation of a fixed RF attenuator of approximately 20 dB, using an RF signal level somewhere near the center of the linear operating range of the system.
2. Adjust the RF signal generator output to a slightly higher level.
3. Using the same reference setting of the precision attenuator as was used in step 1, adjust the receiver gain control to obtain the same output reference reading as was used in step 1.
4. Measure the unknown attenuator at this new signal level.
5. Remeasure the unknown attenuator at other signal levels over the range of interest.

Readings taken in the linear range of the system will be identical. As the nonlinear areas are approached at each end of the range, lower attenuation readings will be obtained. The difference between these reduced readings and the correct attenuation, measured in the linear range, is a measure of the system error caused by the nonlinearity of the mixer-preamplifier at the signal level of the measurement.

5. SIGNAL LEAKAGE ERRORS

When attenuation measurements are made over a large range, errors may occur as a result of signal leakage. During an attenuation measurement, any leakage of the signal around either the RF attenuator or the precision IF attenuator will cause an error. Figure B-4 shows a leakage path around an unknown attenuator.

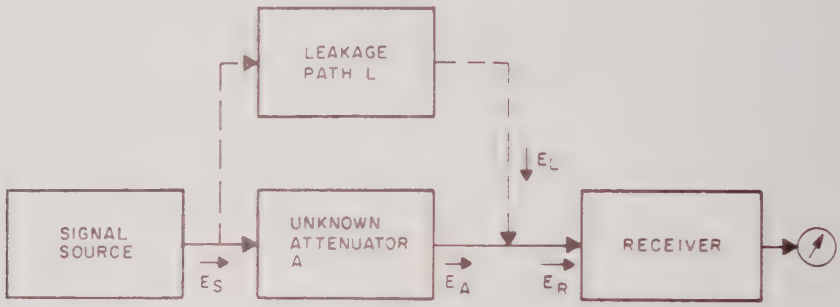


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FIGURE B-4. LEAKAGE PATH AROUND AN UNKNOWN ATTENUATOR

The effect of the signal transmitted transmitted through the loosely coupled leakage path can be calculated as follows:

$$A = \frac{E_S}{E_A}$$

$$L = \frac{E_S}{E_L}$$

where

A = Loss of the unknown attenuator
L = Loss of the leakage path
E_S = Source voltage
E_A = Output voltage of the attenuator
E_L = Output voltage of the leakage path

Since

$$E_R = E_A \pm E_L$$

$$E_R = \frac{E_S}{A} \pm \frac{E_S}{L}$$

and

$$E_R = \frac{E_S}{A}\left(1 \pm \frac{A}{L}\right)$$

Since the voltages E_A and E_L are vector quantities whose relative phase is unpredictable, the quantity A/L represents a maximum uncertainty in the measurement of the unknown attenuation A. The quantities A and L are expressed here as voltage ratios and, therefore, the uncertainty E may be expressed in decibels as

$$E = 20 \log \left(1 \pm \frac{A}{L}\right)$$

As an example, if the signal transmitted through the leakage path is 20 dB lower than that through the unknown attenuator (A/L = 0.1), then the uncertainty of measurement is within the limits of $\pm$0.8 dB.

The actual leakage in a measurement system can be determined by removing the unknown attenuation, terminating both ports of the measurement system, and measuring the decrease in signal level at the receiver as shown in Figure B-5.

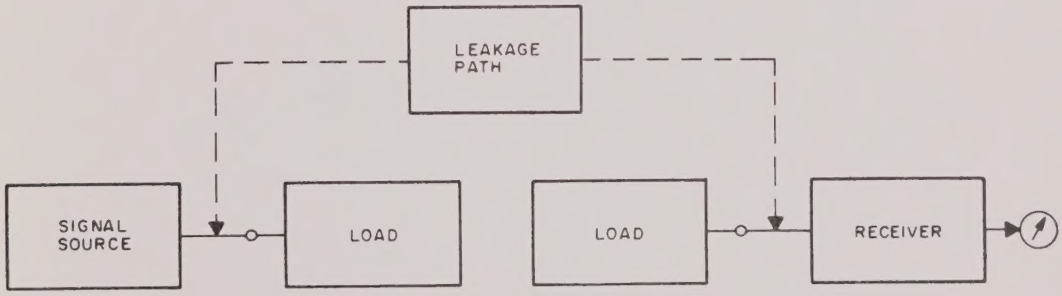

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FIGURE B-5. MEASUREMENT OF LEAKAGE PATH

Careful attention to the selection and arrangement of the component parts of the measurement system can reduce leakage. For instance, coaxial connectors must be in good condition and be properly fitted to the cables, waveguide flanges must be in good condition and properly mated, and the signal source must be adequately shielded and its power line well filtered.